

## **Boosting Collective IQ:**

*A Design for Dramatic Improvements in  
Productivity, Effectiveness and  
Competitiveness*

**Dr. Douglas Engelbart • Bootstrap Institute**

**Bootstrap Management Seminar**  
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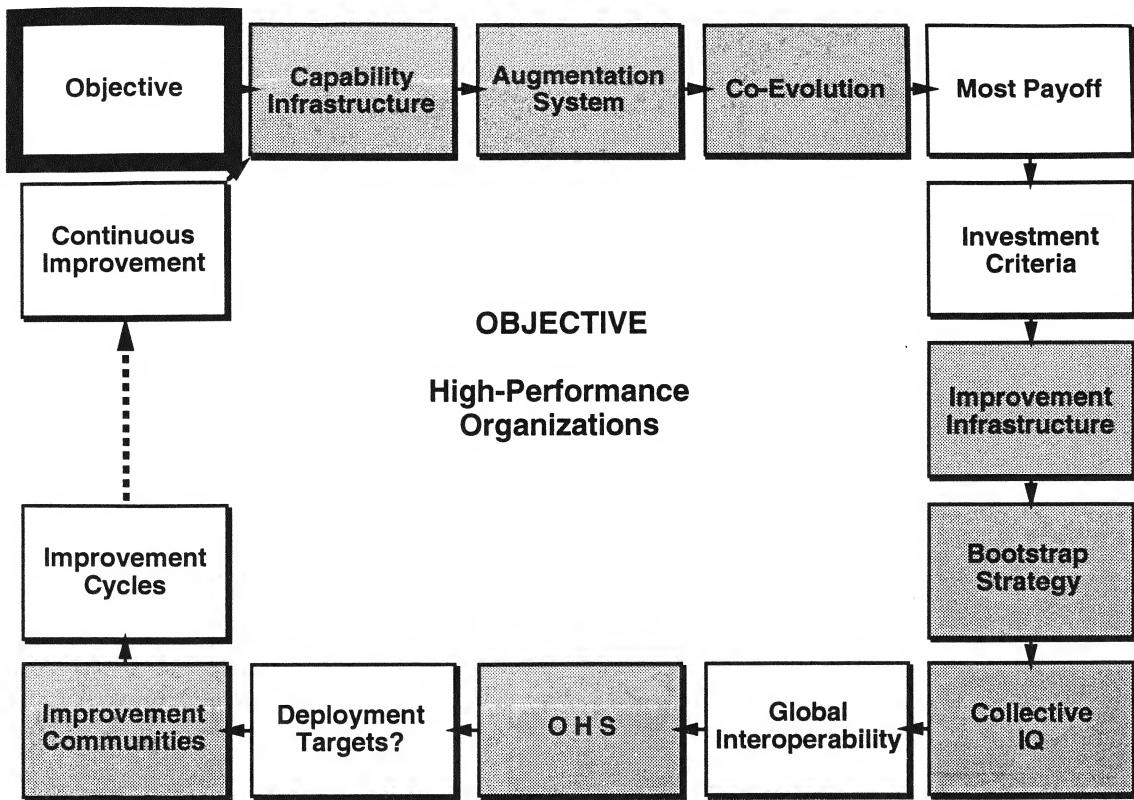
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## ***Selected Reading***

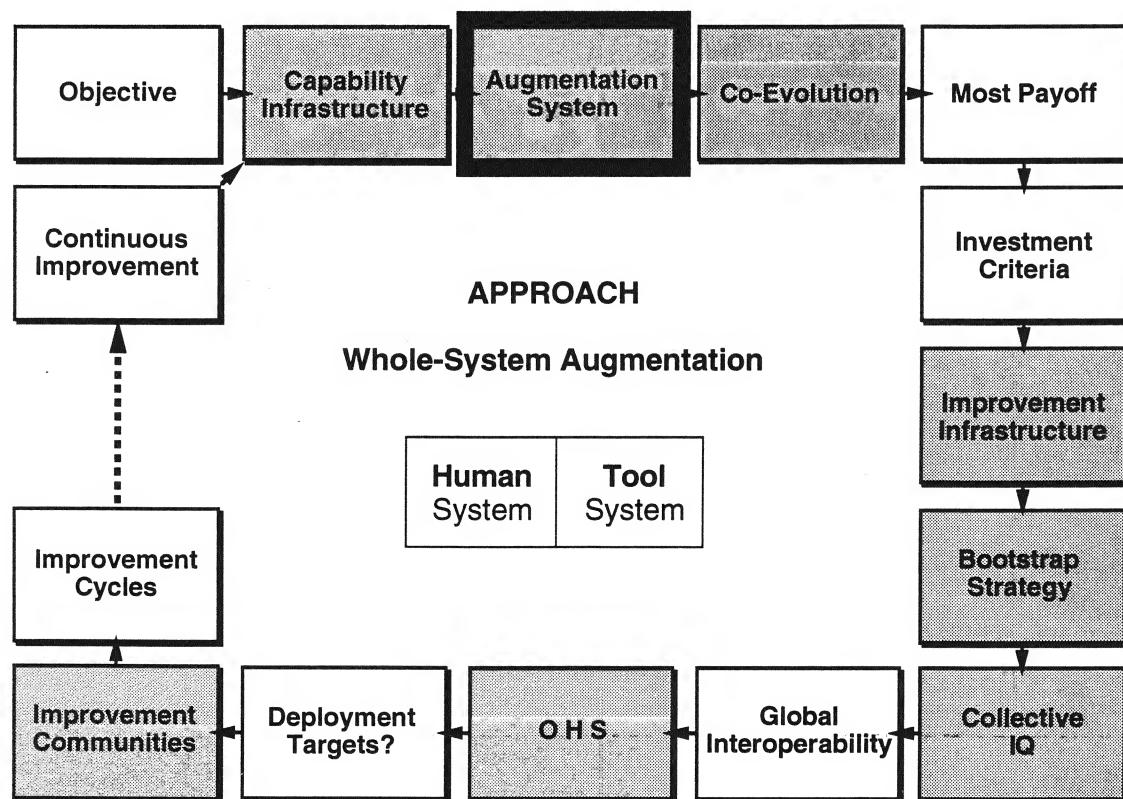
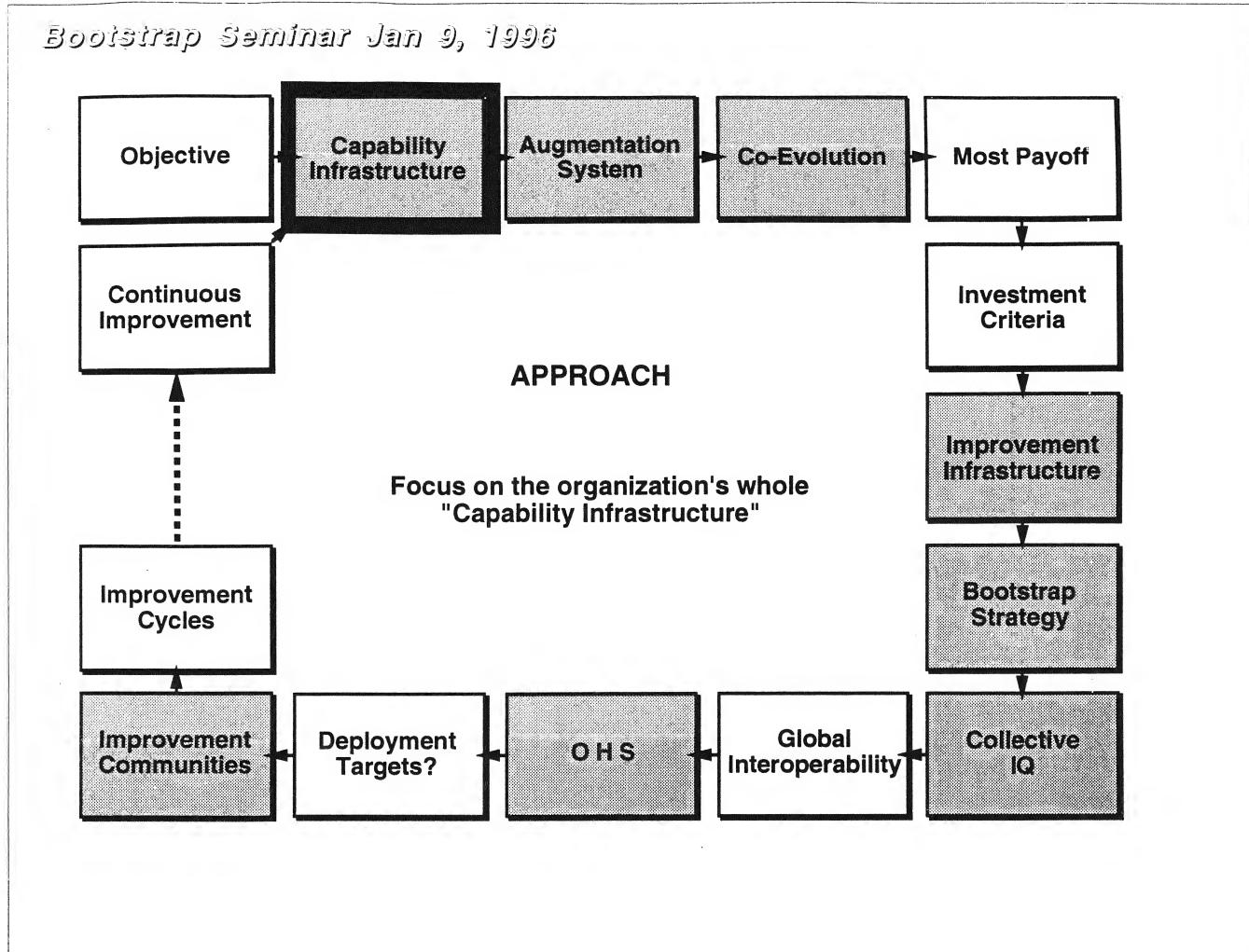
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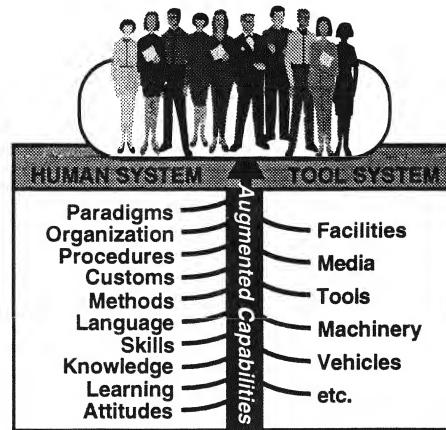
## Notes

**OBJECTIVE**

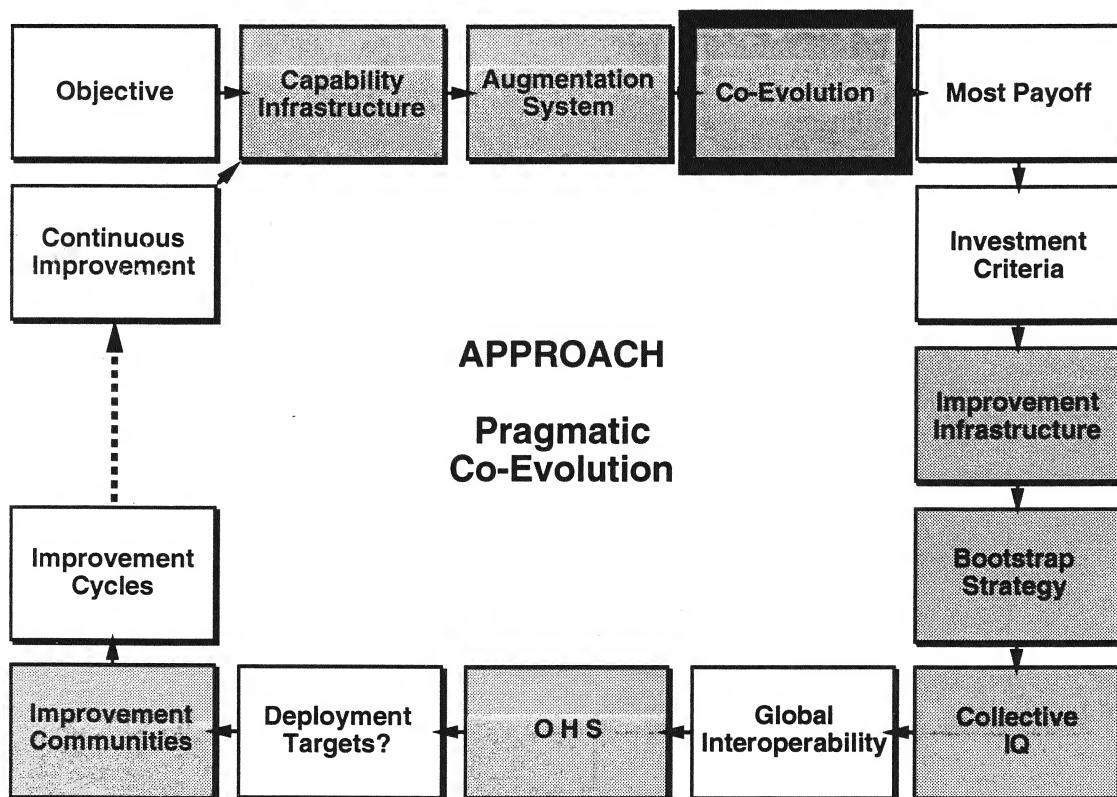
- Coping with complexity and urgency  
→ Collectively
- High-performance
  - individuals
  - teams
  - organizations
  - communities
  - institutions
- Investment Strategy
  - Boosting Collective IQ
  - Boosting Improvement Capability
  - Networked Improvement Communities



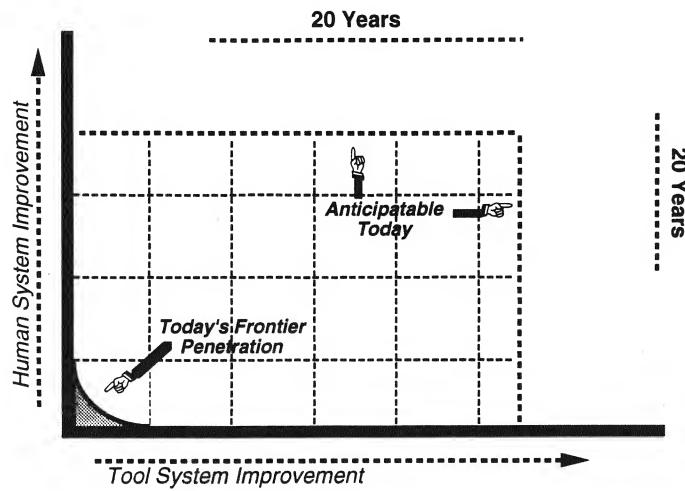
## AUGMENTATION SYSTEM



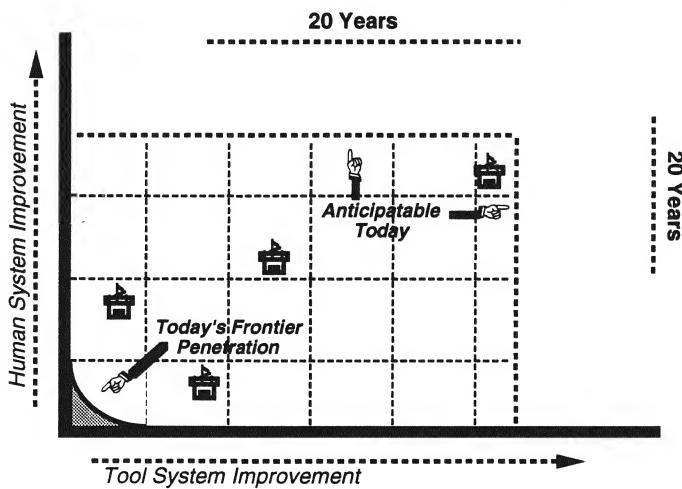
Capability Infrastructure  
= people augmented by  
Human-Tool  
Augmentation System

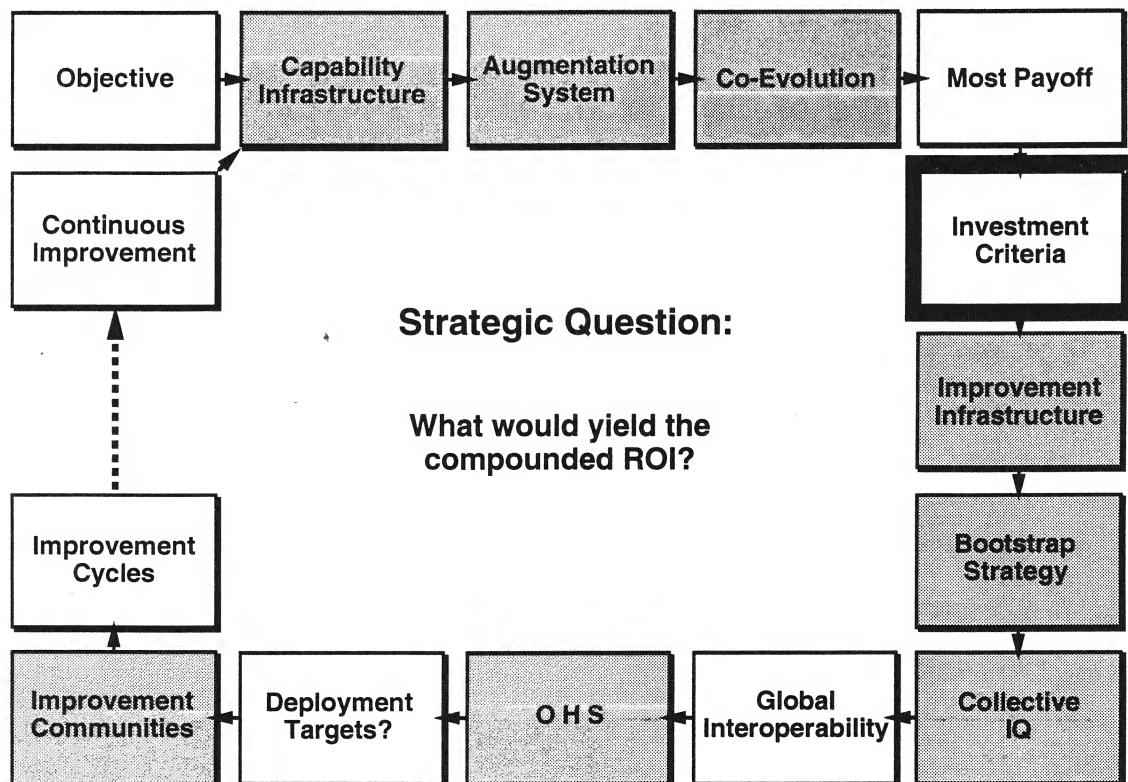
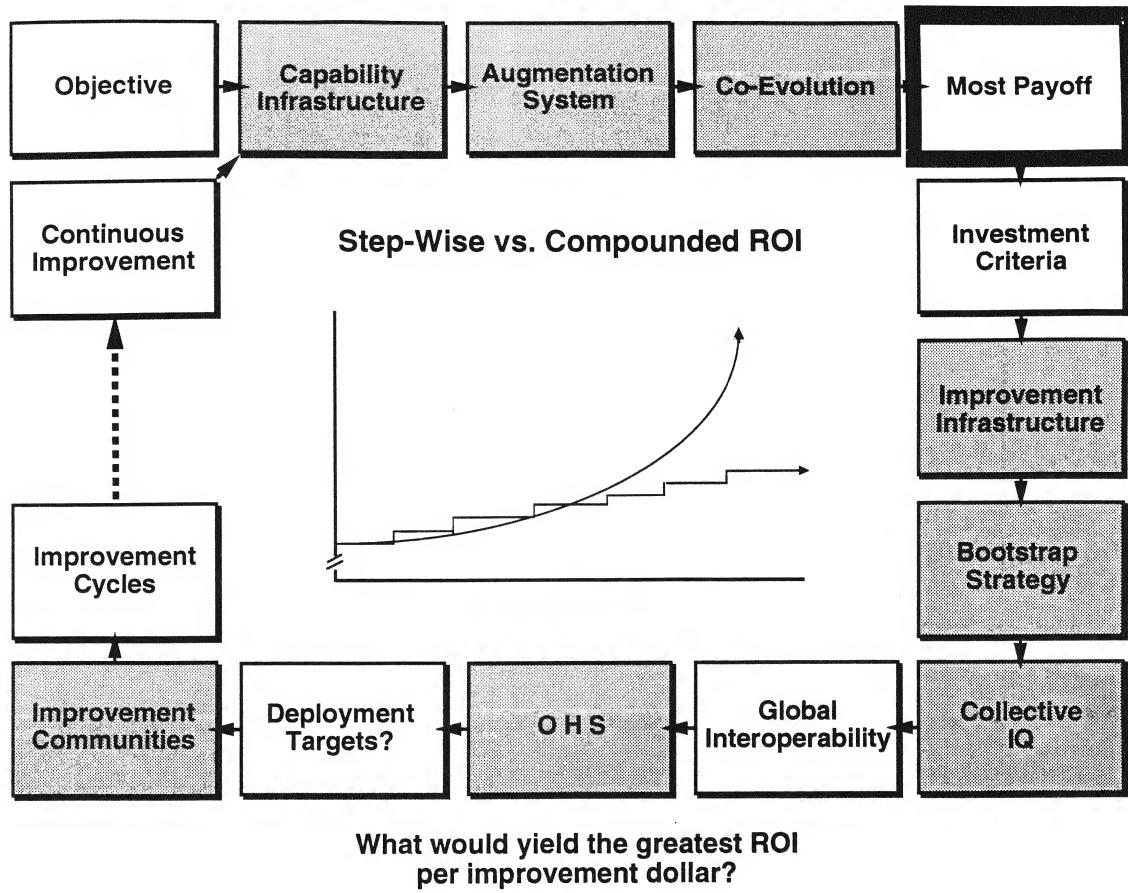


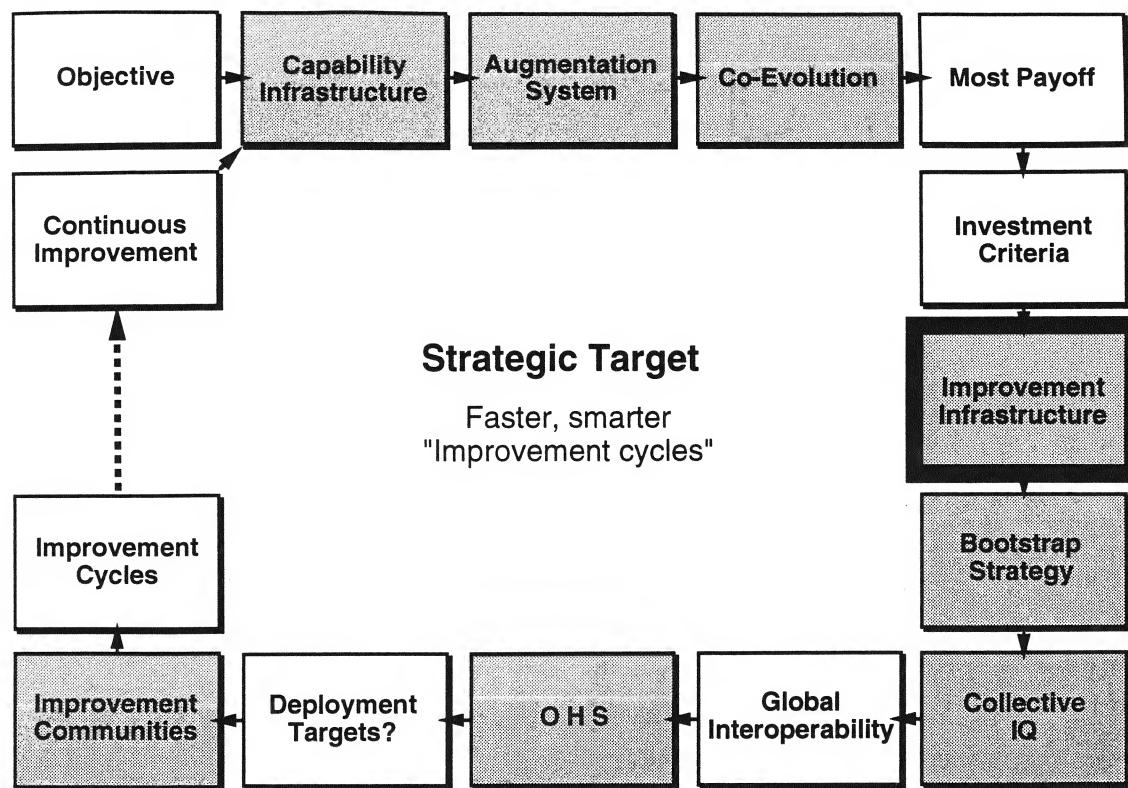
## THE CO-EVOLUTION FRONTIER



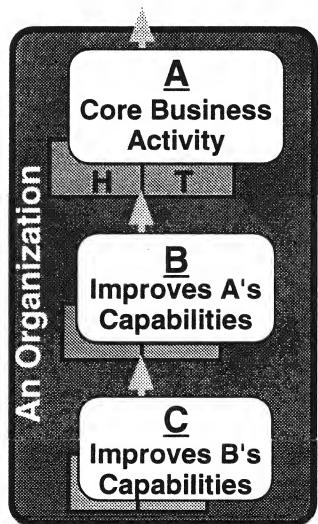
## OUTPOSTS ON THE FRONTIER







### ABC's of Organizational Improvement



#### A Activity:

Product R&D, mfg, marketing, sales, accounting, etc. Ex: aerospace -- producing planes; congress -- passing legislation; medicine -- AIDS research.

#### B Activity:

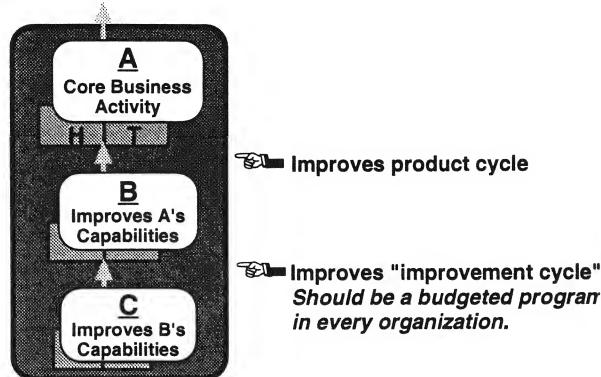
Improving the organization's ability to perform A work. Ex: introducing email or CAD systems; upgrading quality processes.

#### C Activity:

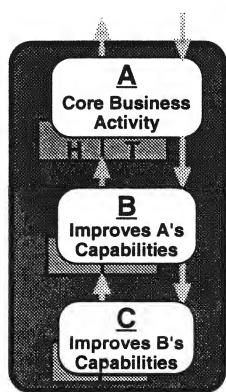
Improving the organization's ability to perform B work. Ex: introducing better ways to address needs, or run pilots.

How an organization explicitly improves its improvement capability.

### An Organization's Improvement Infrastructure



### Pushing Frontier Requires Collaboration

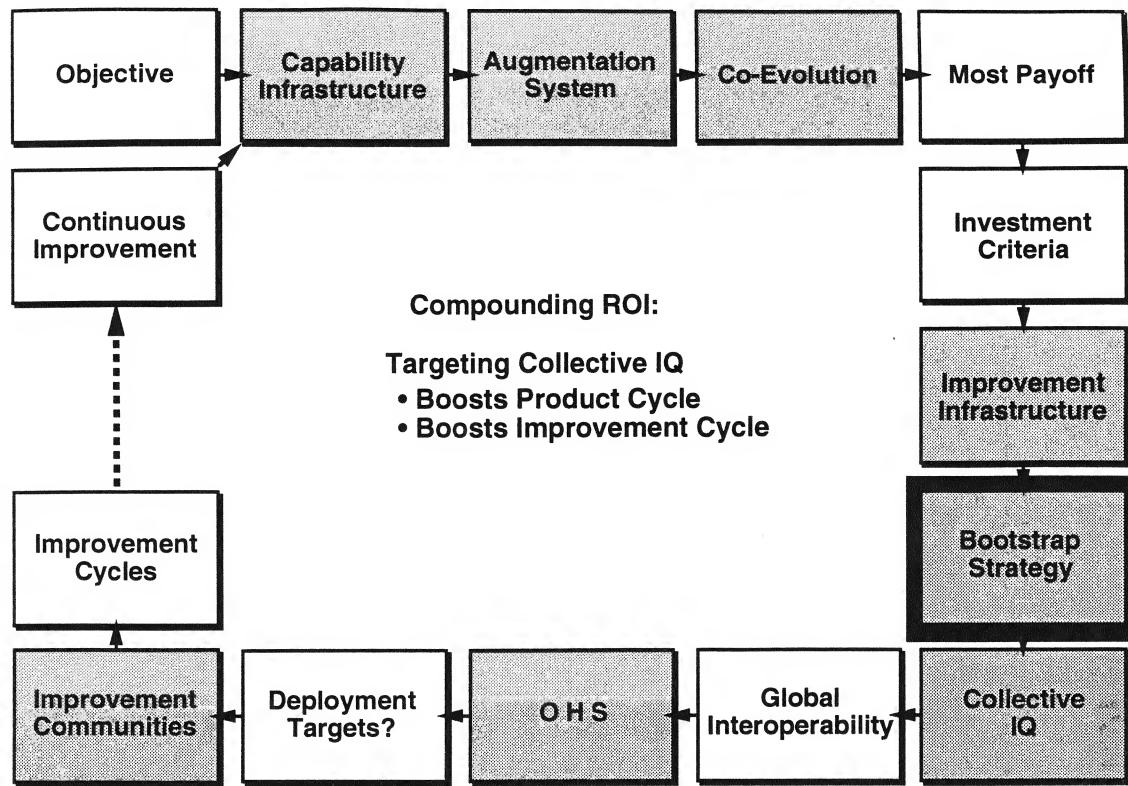


#### Integrating ↓:

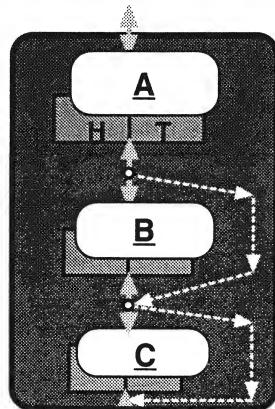
- Input
- Feedback
- Requirements
- Lessons learned
- Intel
- Evaluations
- Evolving deliverables

#### Transferring ↑:

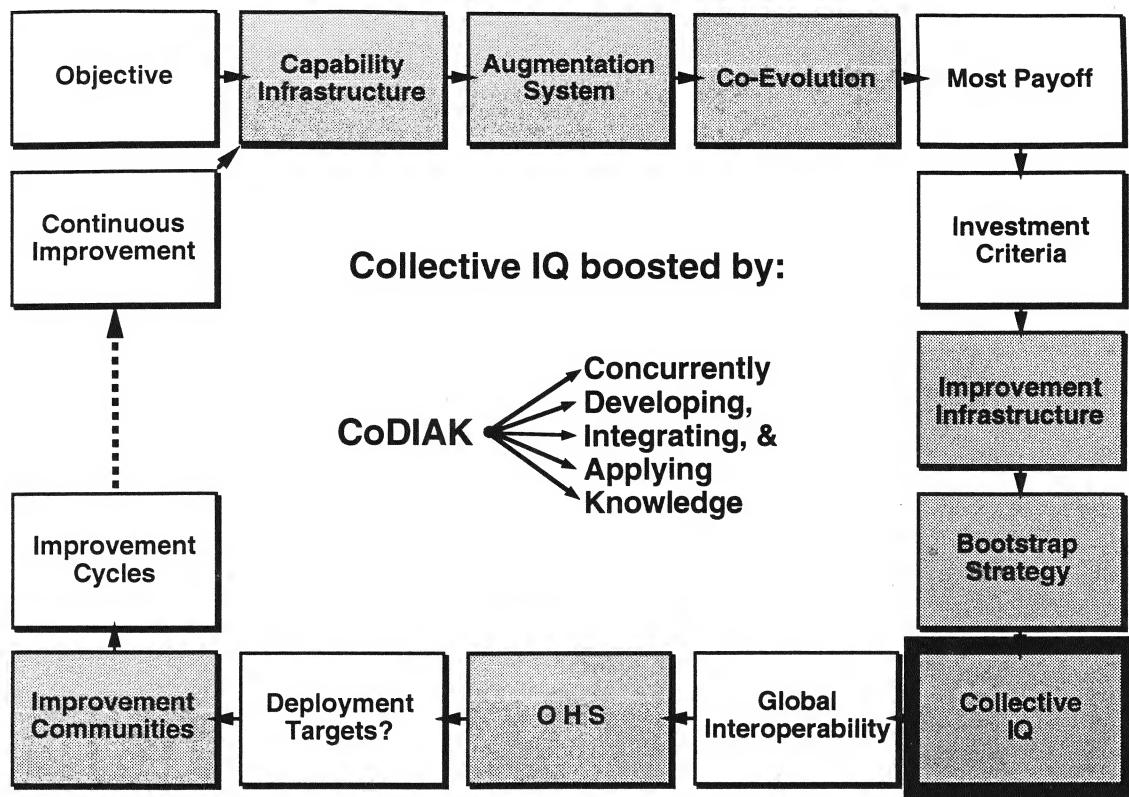
- Paradigm shift
- "Selling"
- Designs
- Planning transfer
- Implementing
- Followup support



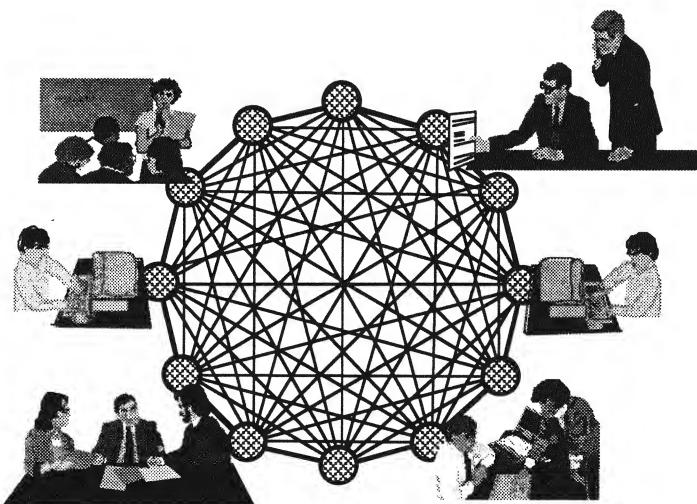
#### EXTRA BOOTSTRAPPING LEVERAGE



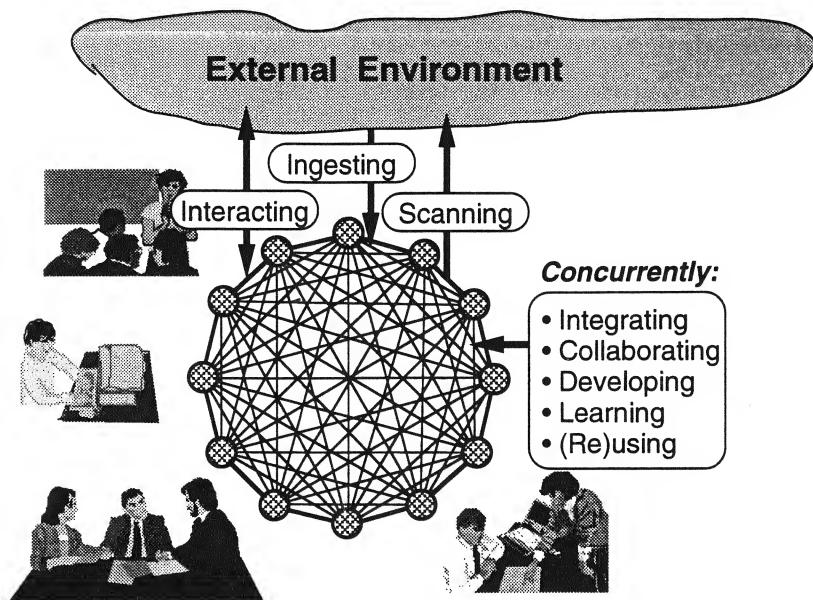
**Boosting Collective I.Q.  
+ Boosting Improvement Capability  
= Yields Compounding ROI**



# Collective IQ: How Well People Work Collectively

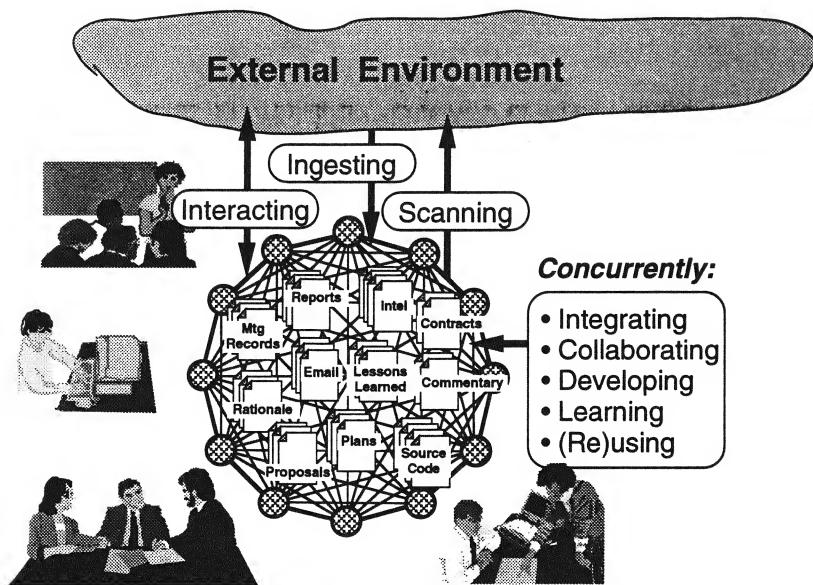


## ENGAGED IN BASIC KNOWLEDGE PROCESSES

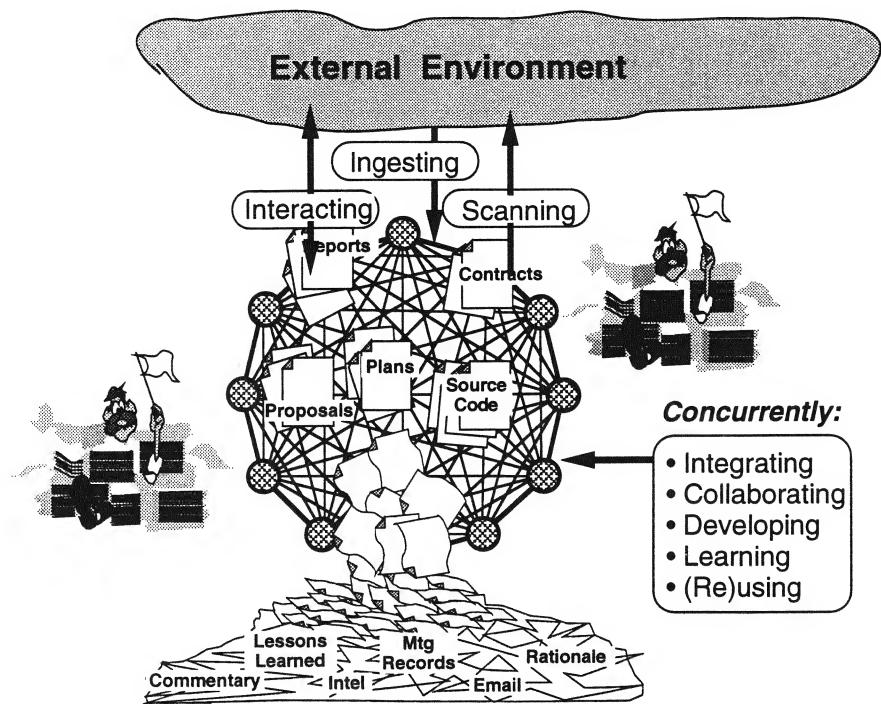


Every viable organizational unit requires basic knowledge processes.

## AN EVOLVING KNOWLEDGE BASE EMERGES

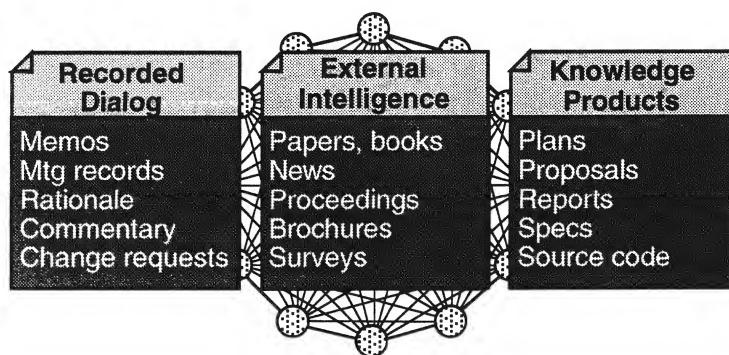


## TODAY'S CoDIAK SUPPORT

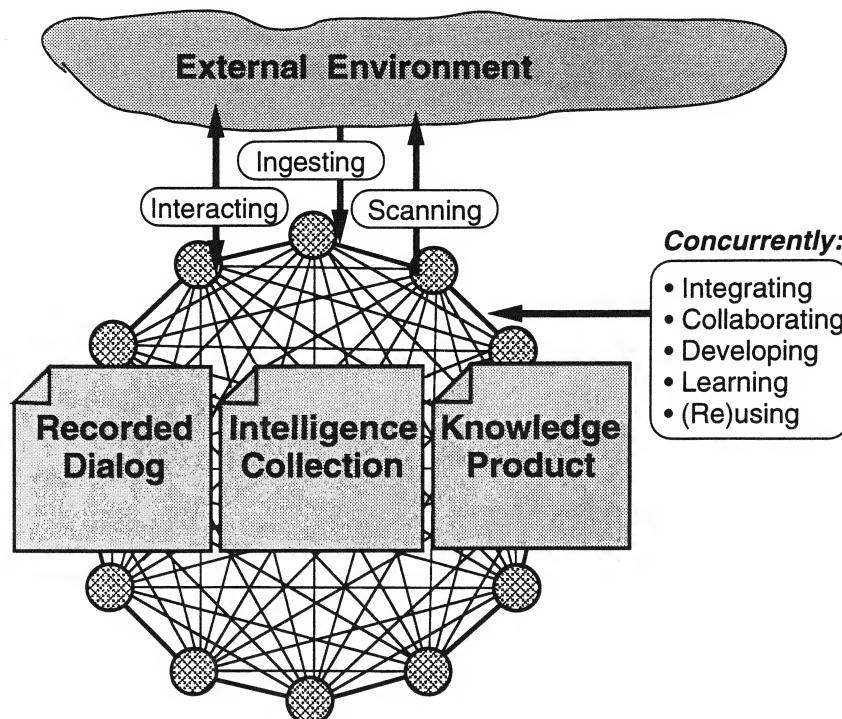


Most knowledge assets are not useable, or not captured.

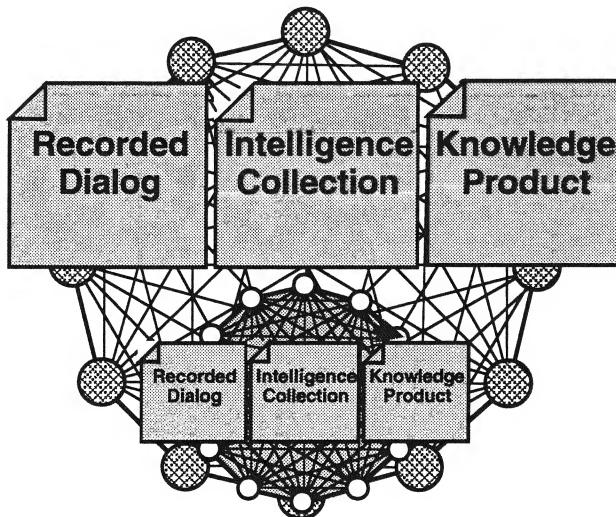
## USEFUL CATEGORIZATION OF EVOLVING KNOWLEDGE



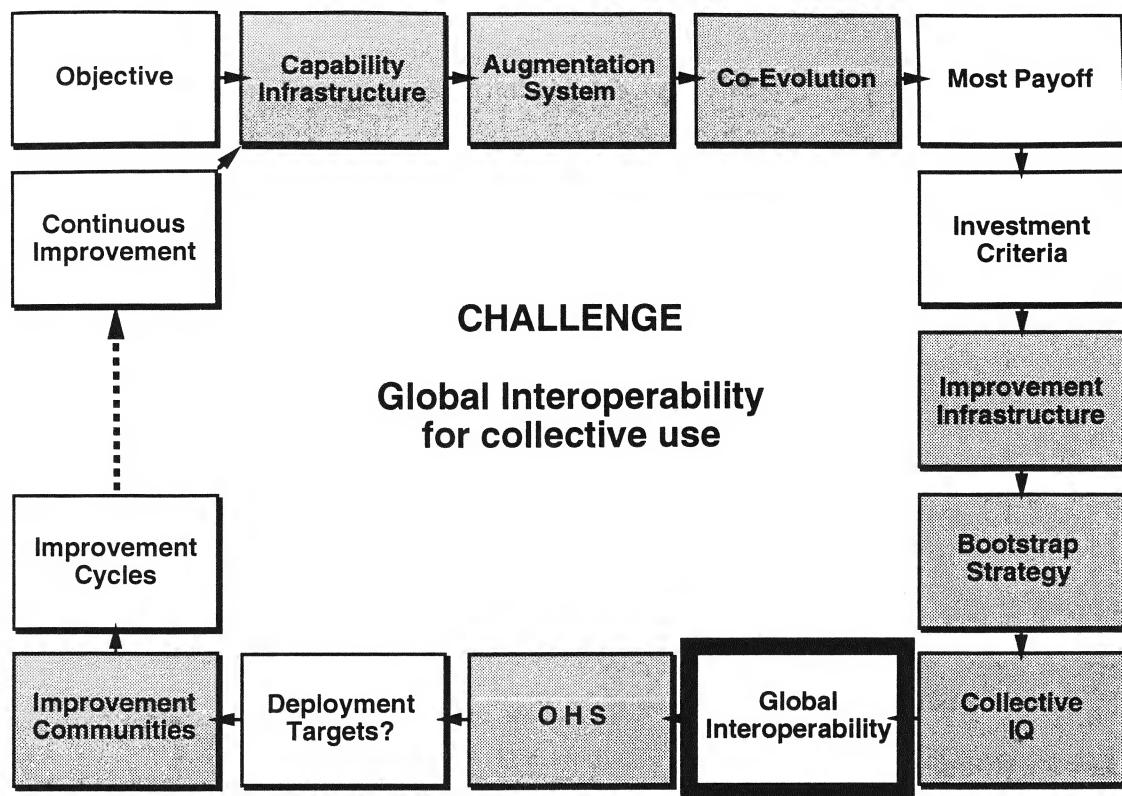
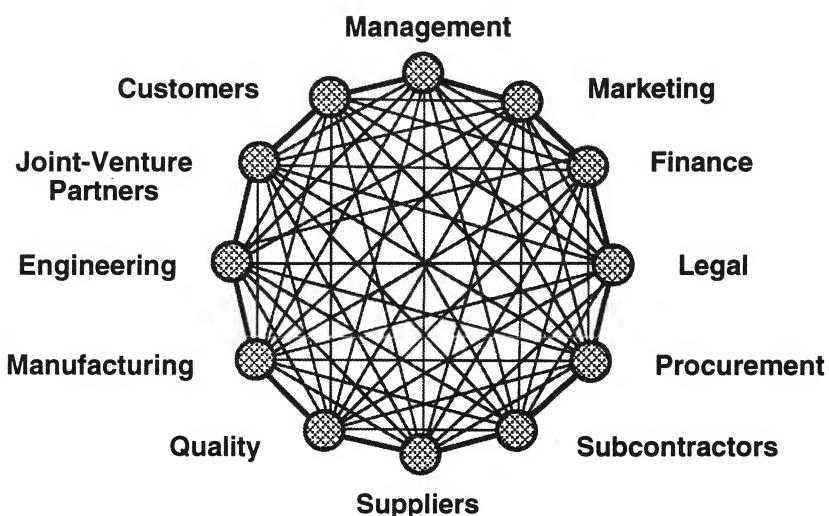
## COLLECTIVE IQ DEPENDS ON CoDIAK



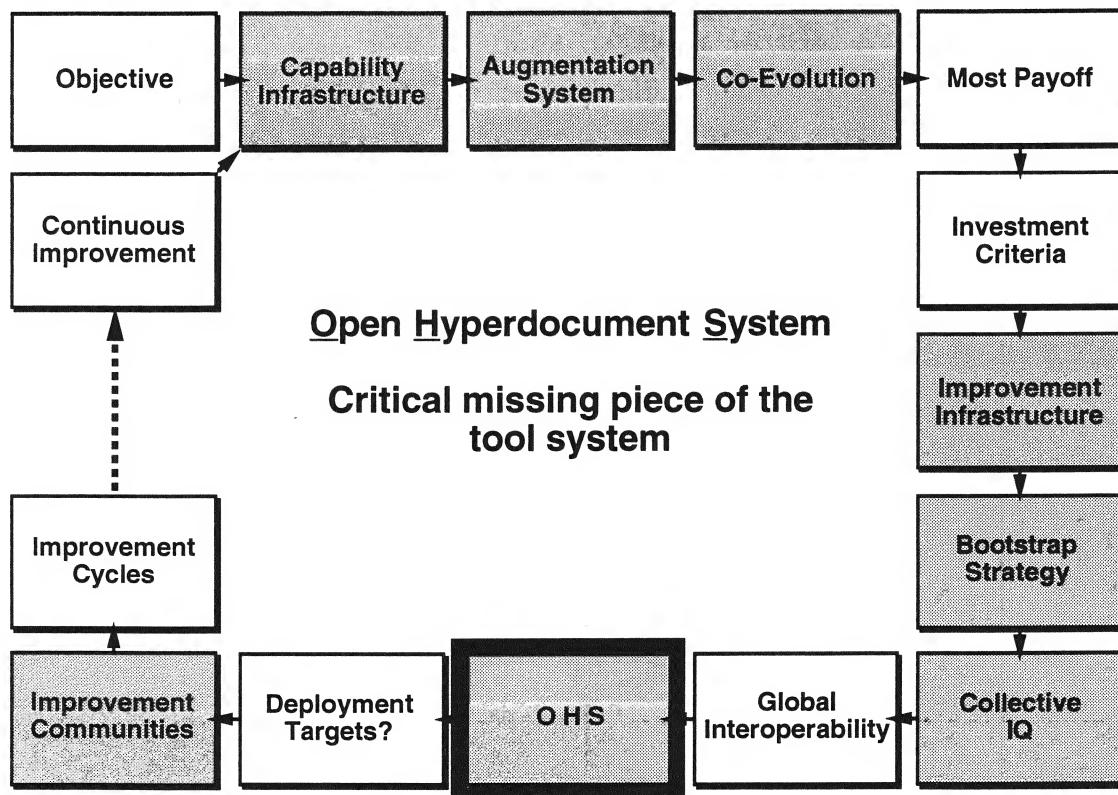
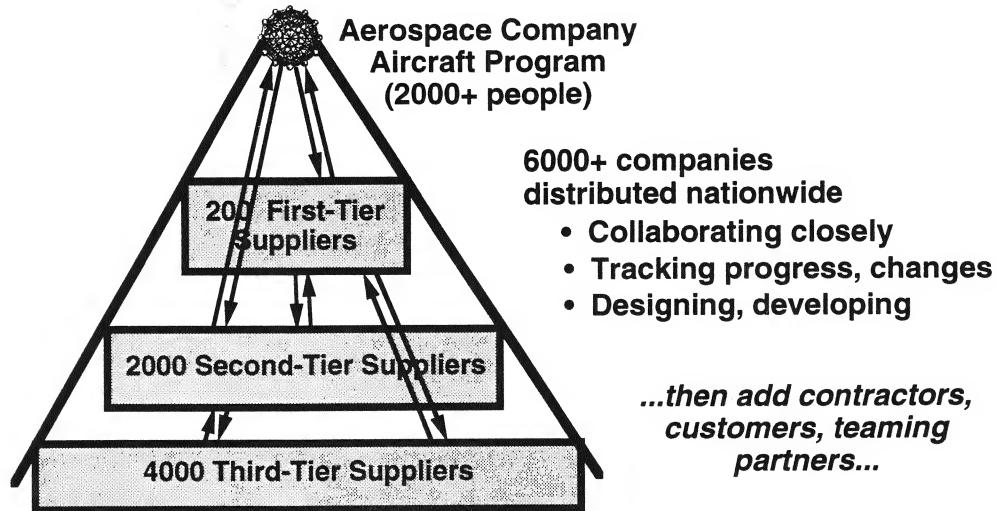
## CONCURRENCY SCALES UP IN THE ORGANIZATION



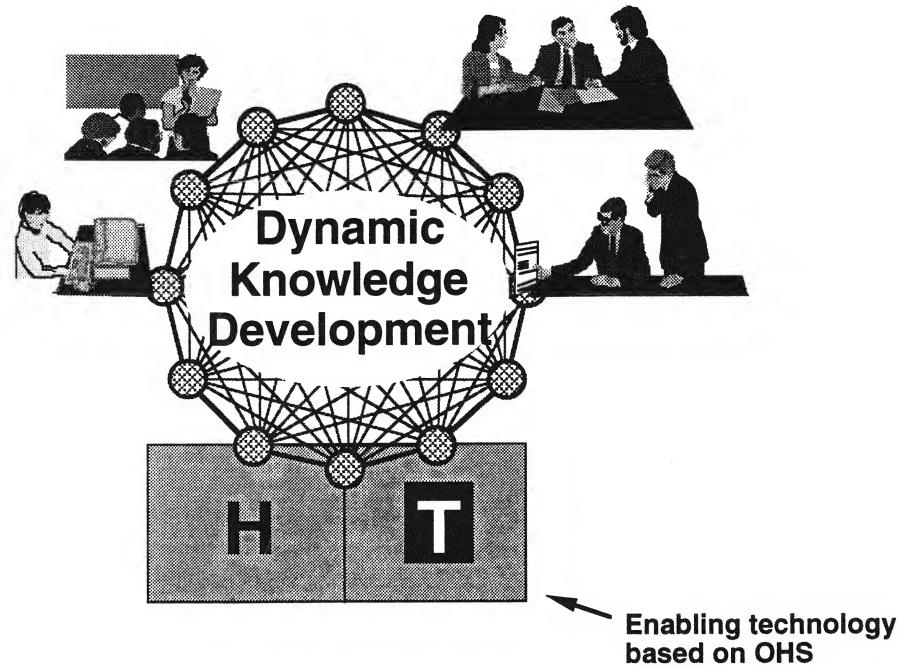
An organizational unit's CoDIAK process intersecting and nested in other organizational efforts

**EXAMPLE: MANUFACTURING ORGANIZATION**

## Example: Knowledge Exchange in Supplier Hierarchy



## OHS TECHNOLOGY NEEDED TO BOOST COLLECTIVE IQ



## OHS ENABLING TECHNOLOGY

### A Collaborative Hyperdocument Environment:

- Hypermedia for "real work"
- Interoperable, evolvable, scalable

### Facilitating:

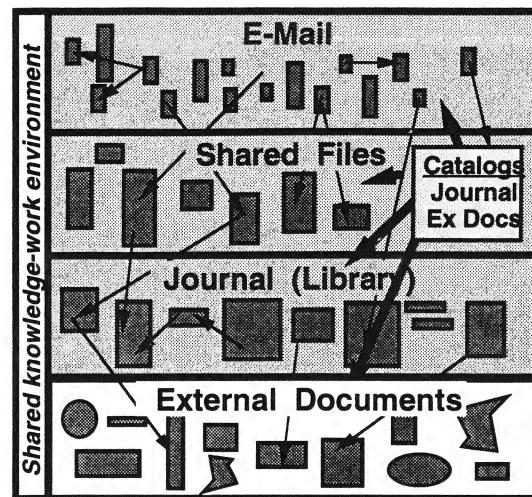
- Evolutionary, heterogeneous knowledge work
- Automated capture, management
- Added-value utilization
- Collaborative processes

## OHS To Support CoDIAK Work

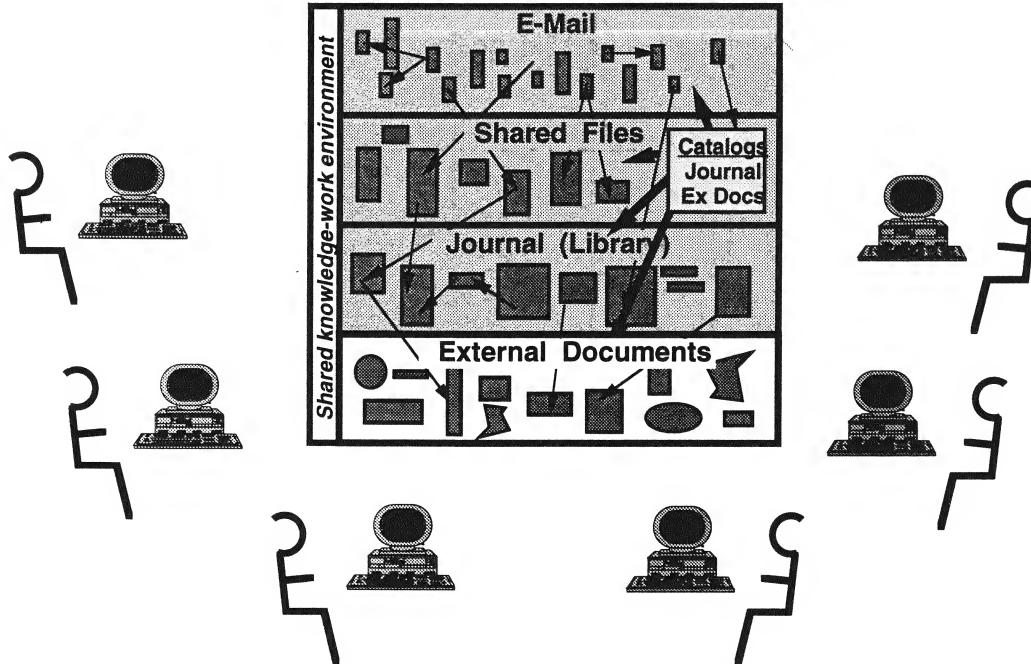
### Underlying Foundational Elements

- Multi-media
- Structured outlining
- Object linking and addressing
- View control
- Comprehensive browser/editor
- Shared screen
- Scripting

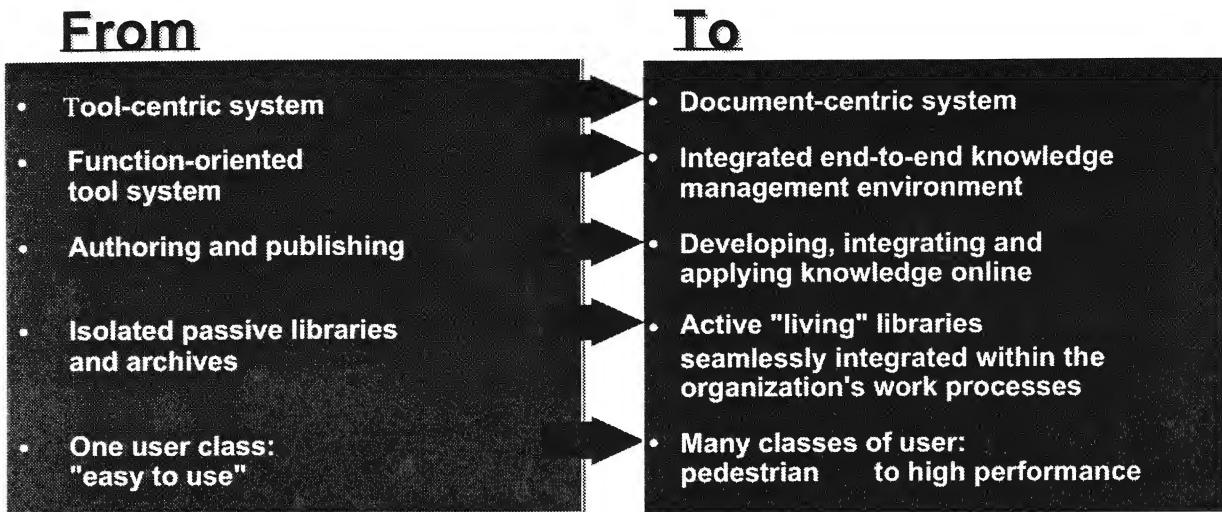
### CoDIAK Example



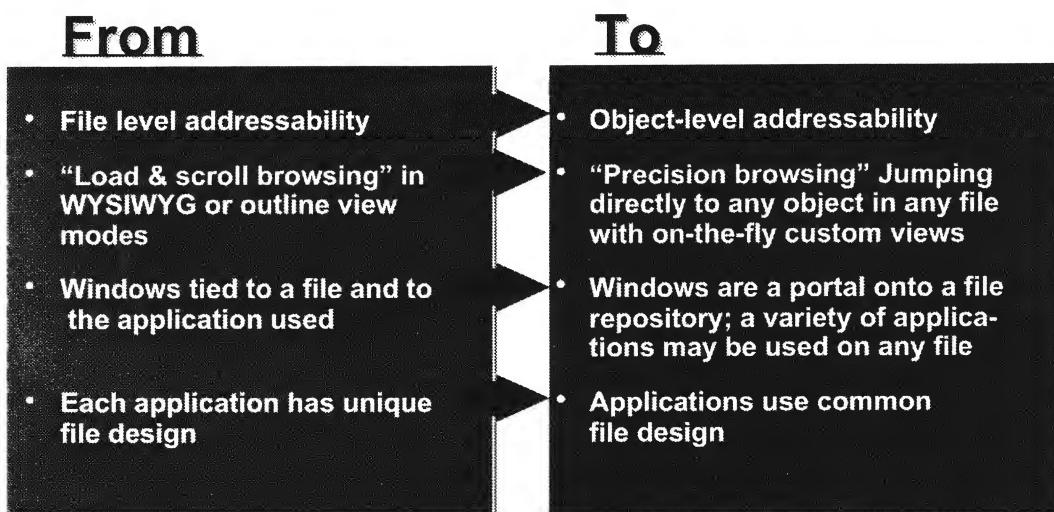
## OHS: To Support CoDIAK Work



## OHS Represents a Paradigm Shift



## Paradigm Shift (cont.)



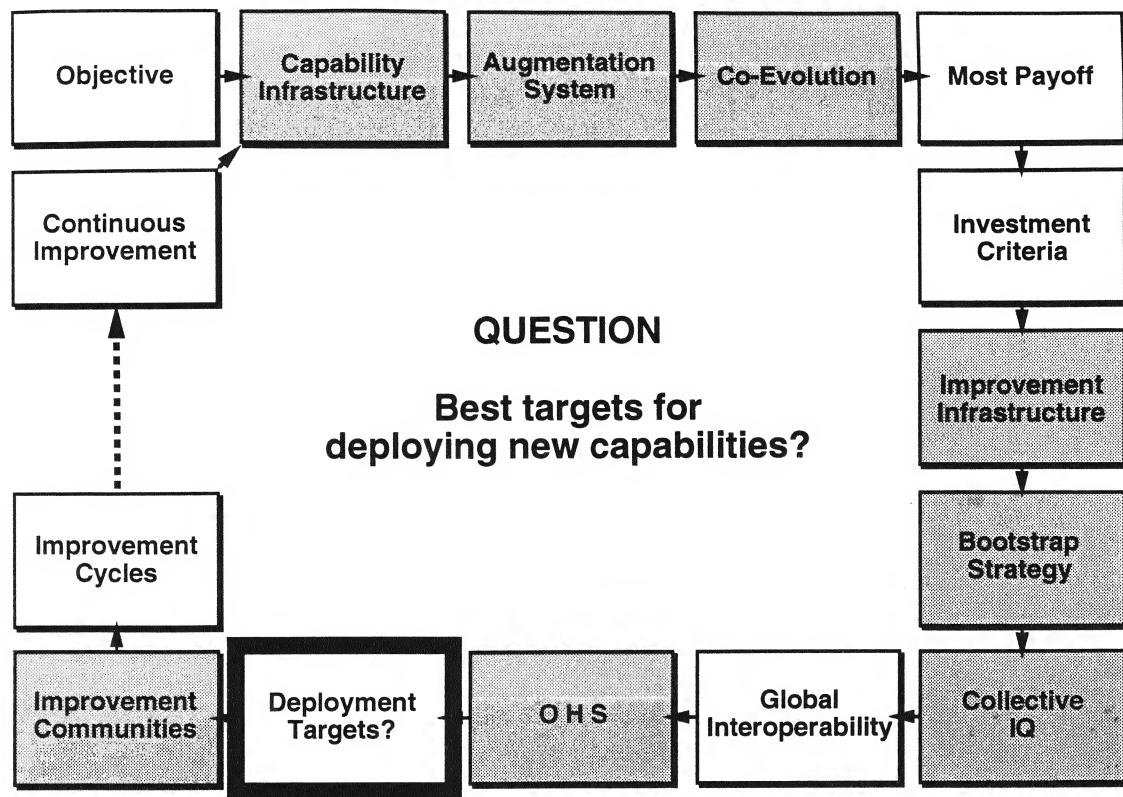
## **Potential OHS Applications: To Support and Integrate CoDIAK-Intensive Work**

- Program Management
- Collaborative Planning & Tracking
- Command and Control
- Concurrent Engineering
- Software Engineering (CASE)
- Acquisitions Support (CALS)
- CA- Integrated Architectures
- Contracts Management
- World Wide Web
- Records Management
- Digital Libraries
- Tele-Commuting
- Online Document Delivery
- Groupware, CSCW
- Enterprise Integration
- Total Quality Management
- Continuous Process Improvement
- Re-Engineering
- Organizational Learning
- Distance Learning
- Technology Transfer
- Networked Improvement Communities \*
- etc.....

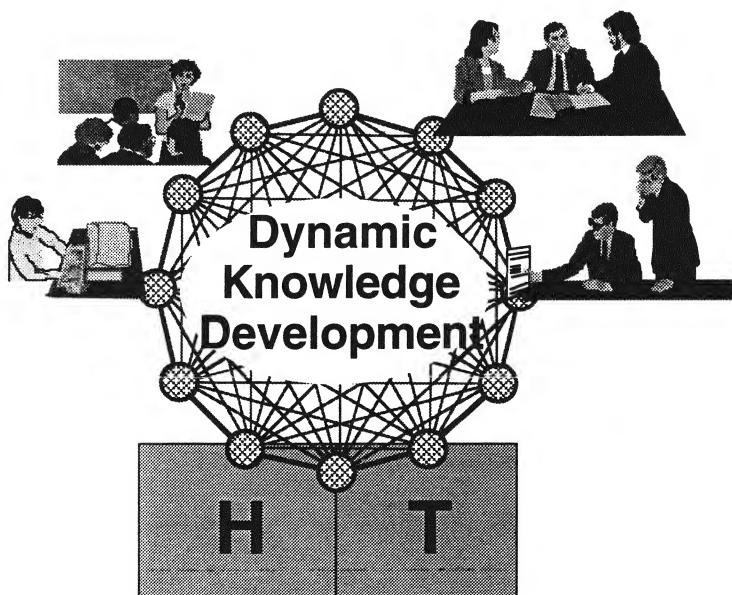
\* Provides Compounding ROI

## **OHS Development Needed**

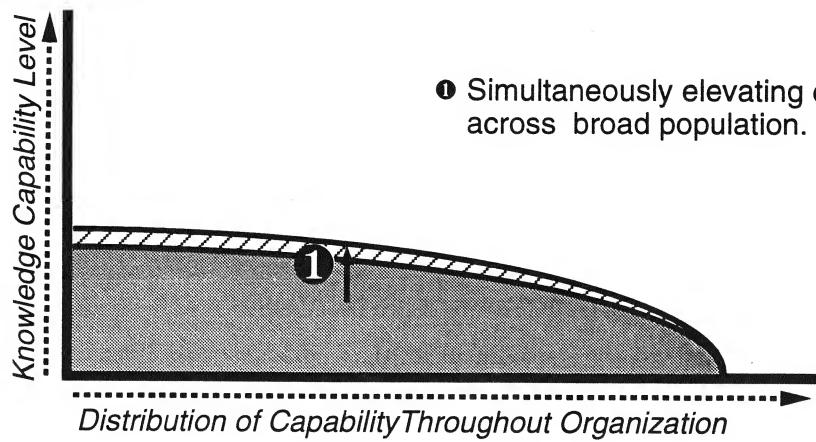
- Exploratory prototypes
- Commercial spinoffs
- Open standards for mainstream commercialization



# PUSHING INTO FRONTIER REQUIRES HUMAN-TOOL CO-EVOLUTION

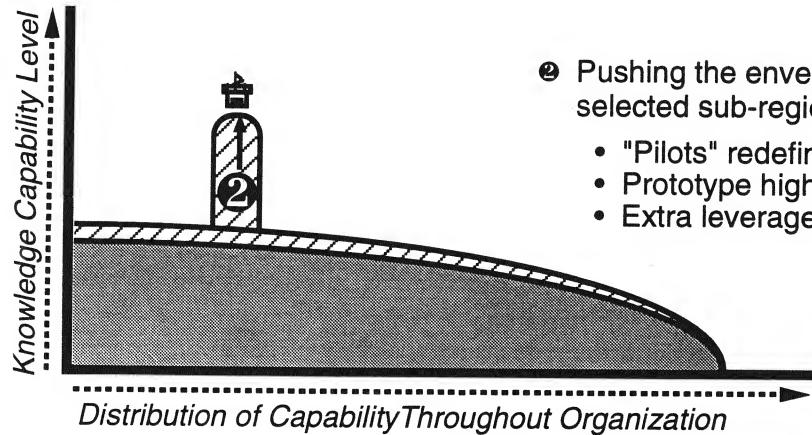


## MODE (1) INCREASING ORGANIZATIONAL CAPABILITY



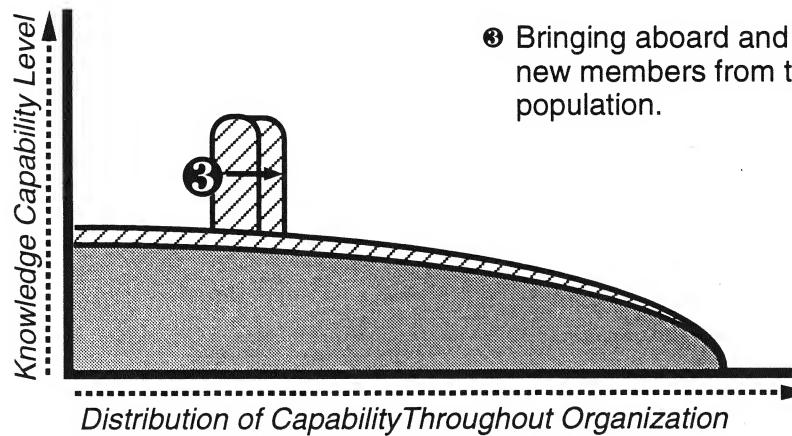
- ➊ Simultaneously elevating capability across broad population.

## MODE (2) INCREASING ORGANIZATIONAL CAPABILITY



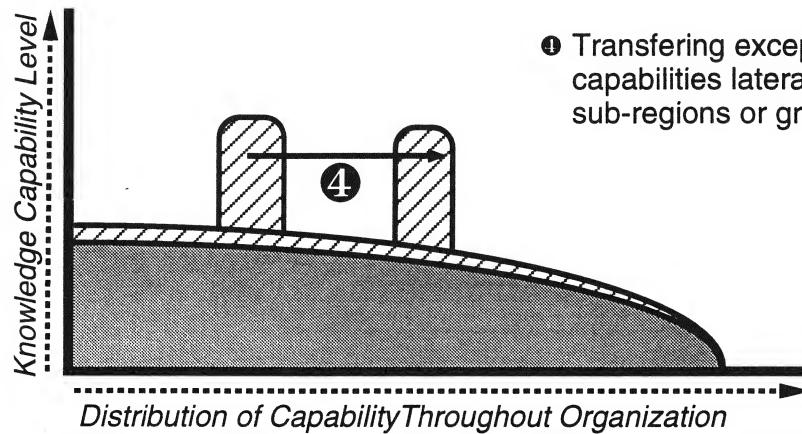
- ➋ Pushing the envelope within a selected sub-region or -group.
  - "Pilots" redefined
  - Prototype high-performance team
  - Extra leverage if NIC

### MODE (3) INCREASING ORGANIZATIONAL CAPABILITY



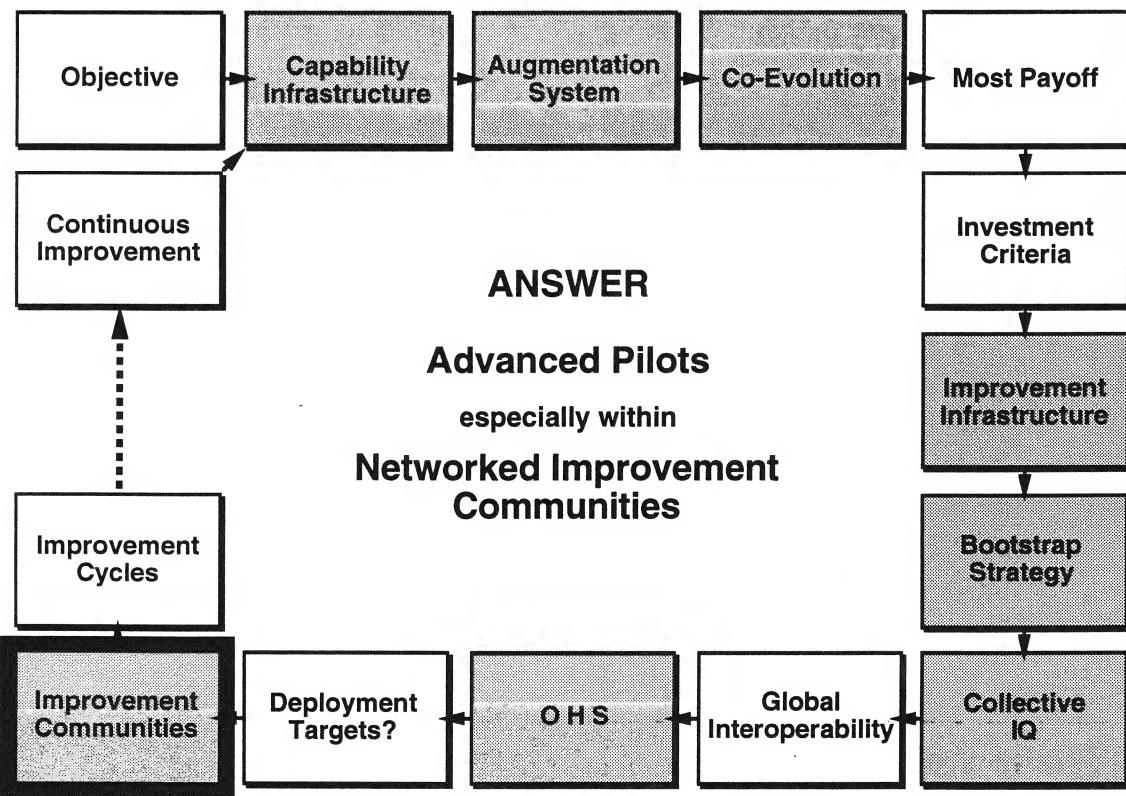
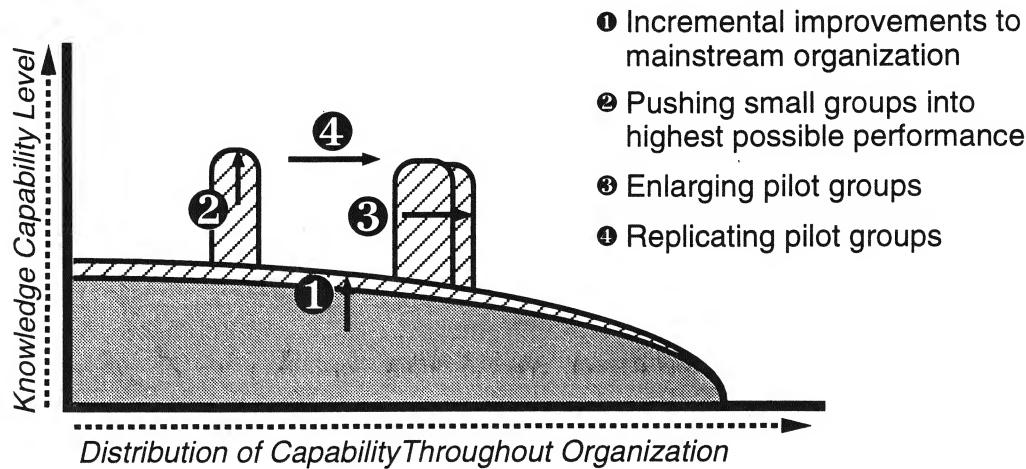
- ③ Bringing aboard and training new members from the larger population.

### MODE (4) INCREASING ORGANIZATIONAL CAPABILITY

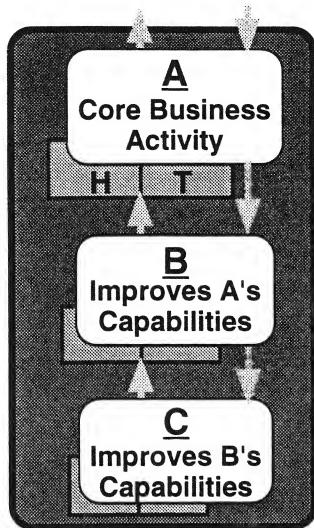


- ④ Transferring exceptional new capabilities laterally to other sub-regions or groups.

# Multi-Faceted Deployment Strategy

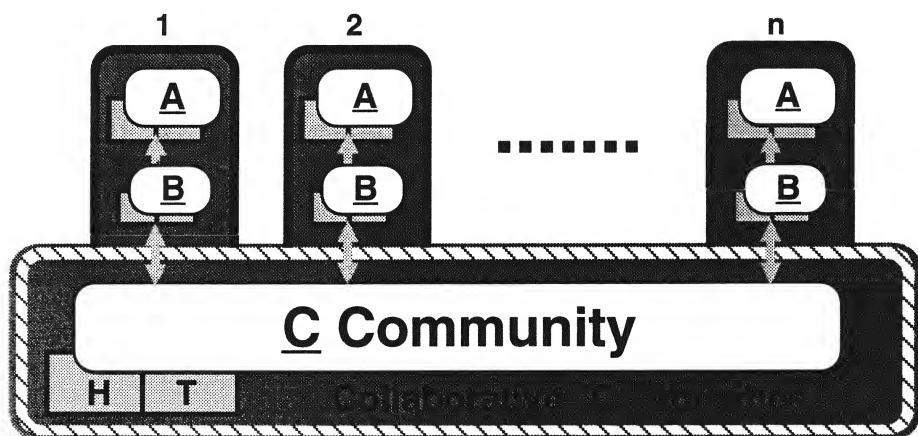


## BACK TO THE ABC MODEL



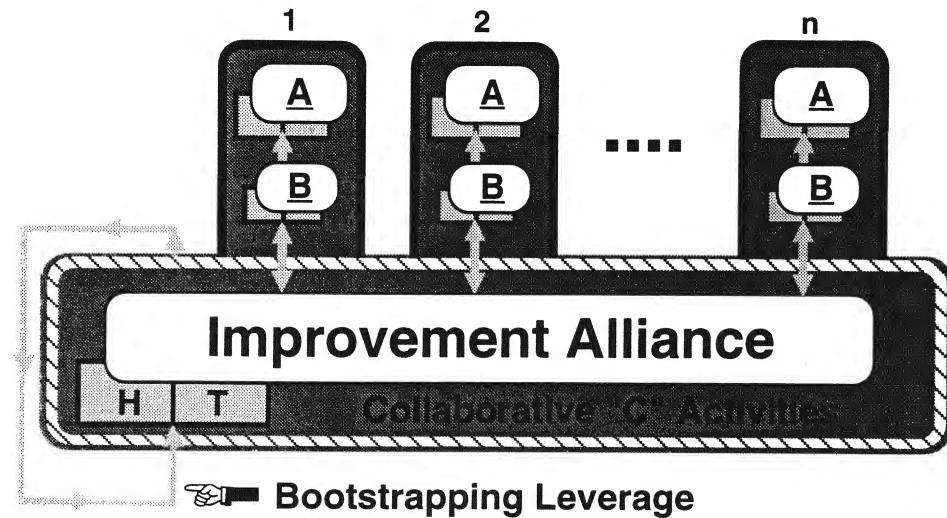
- ☞ Improves Product Cycle
- ☞ Improves Improvement Cycle

## C ACTIVITIES JOINING FORCES

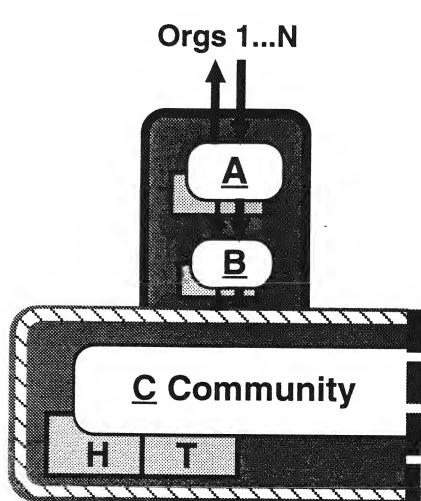


Working on common challenges, issues, requirements

## NETWORKED IMPROVEMENT COMMUNITY

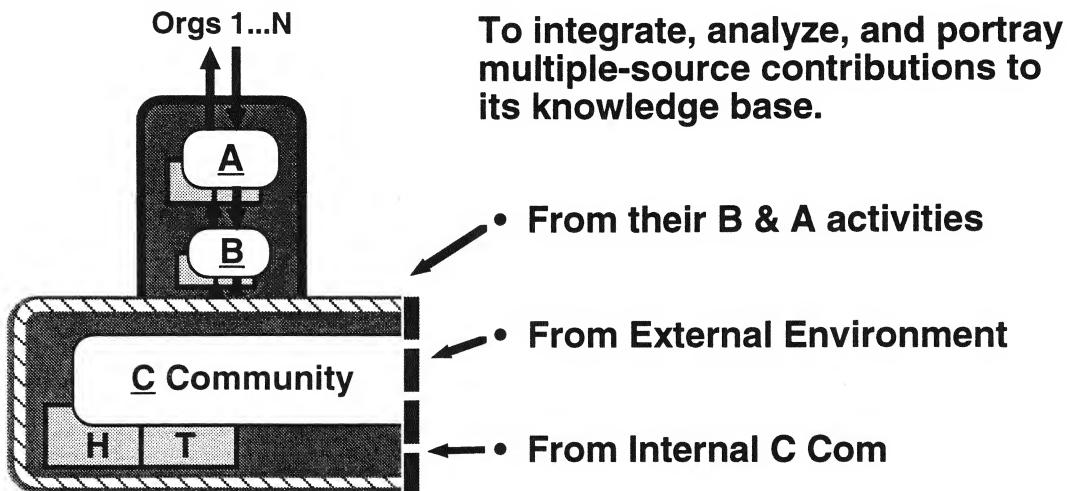


## NETWORKED IMPROVEMENT ALLIANCE A PRO-ACTIVE WORKING GROUP

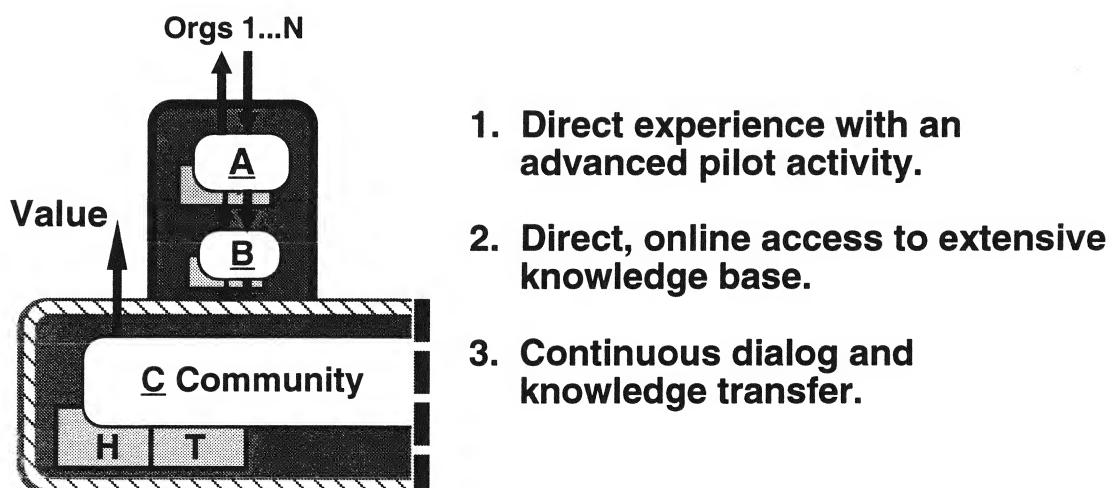


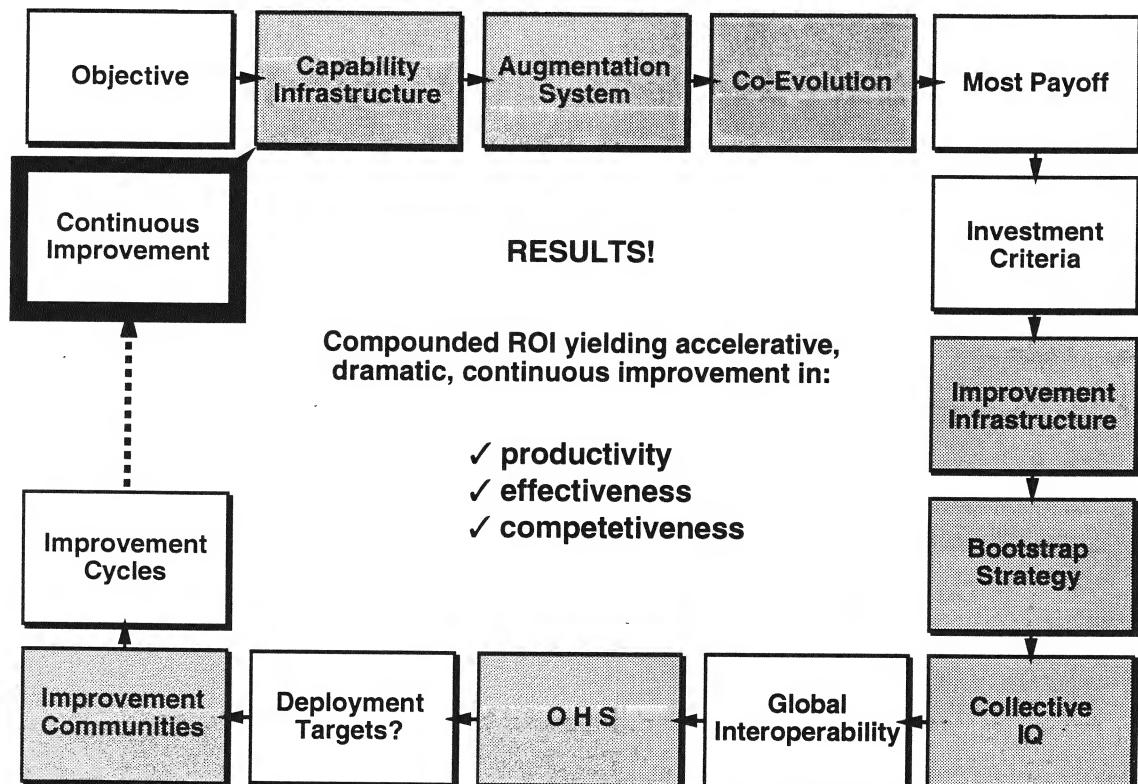
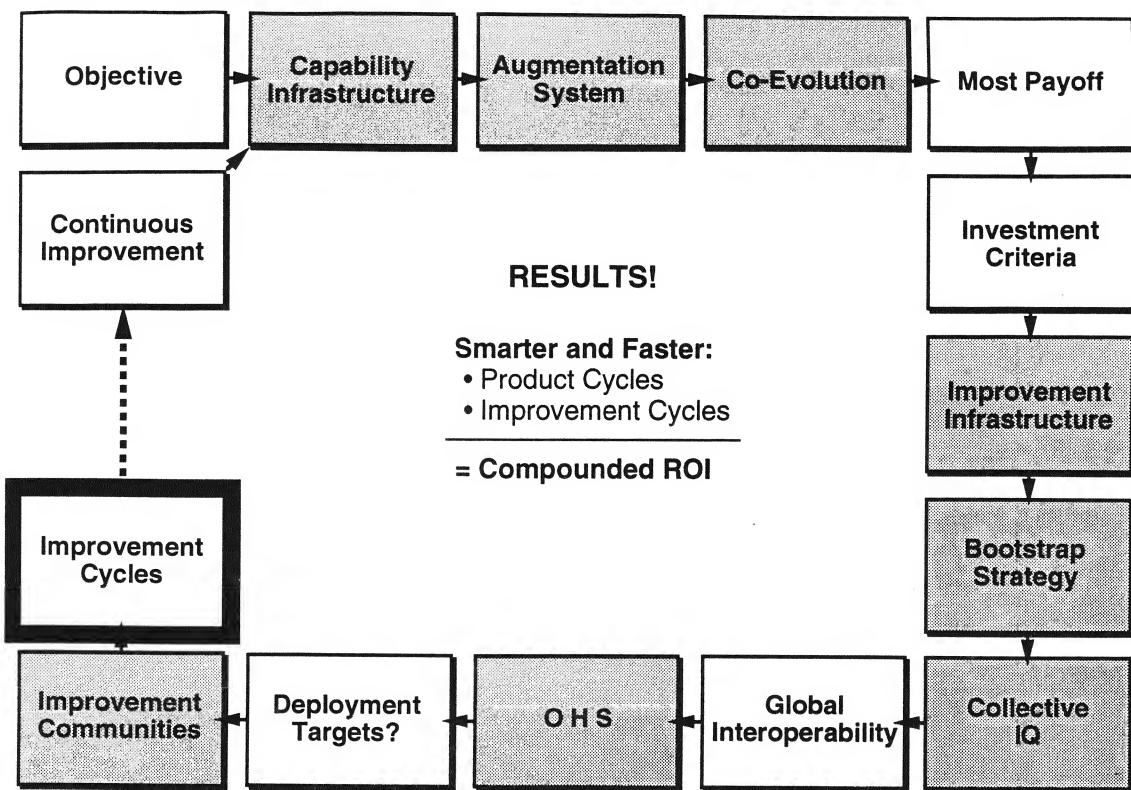
- Finding solutions to common challenges
  - boosting Collective IQ
  - boosting Improvement Capability
  - etc.
- Push into frontier with advanced exploratory pilots
- Support member pilots
- Co-evolving OHS and Human-System prototypes
- Extensive intelligence collection, evolving collective knowledge repository
- Work with providers and standards groups

## CORE C-COM CAPABILITY



## PARTNER ORGS GET UNIQUE VALUE

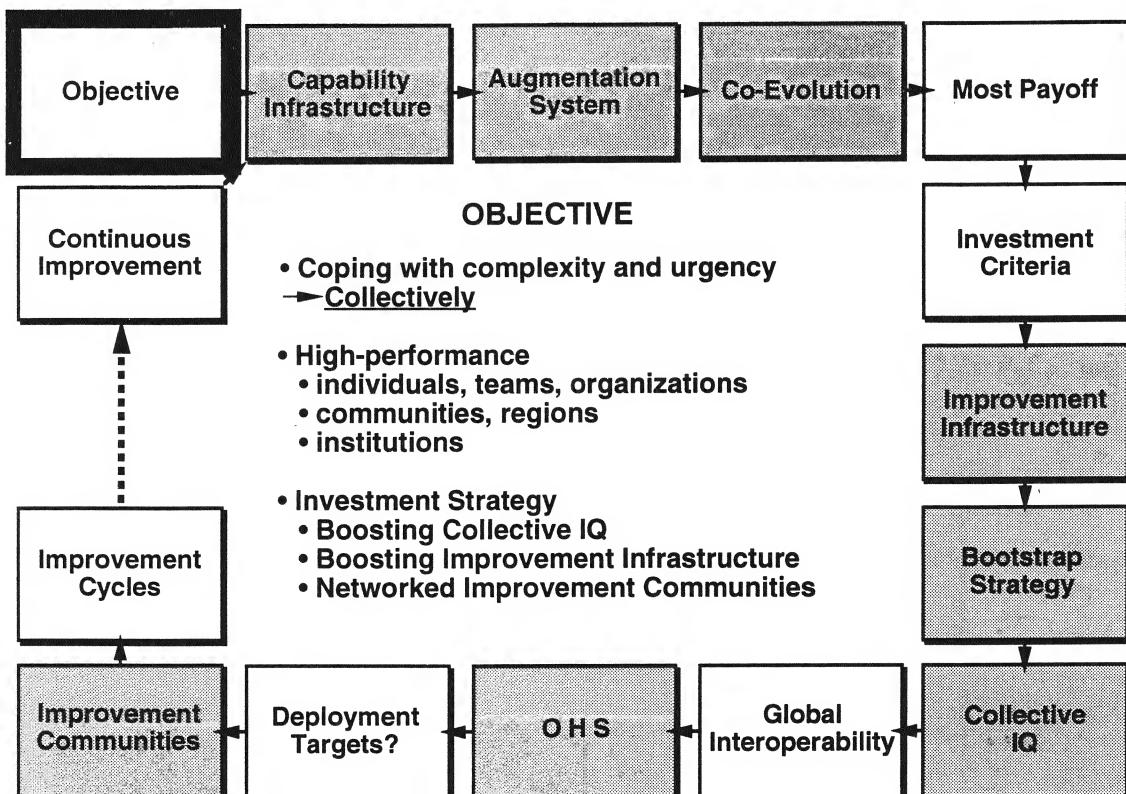
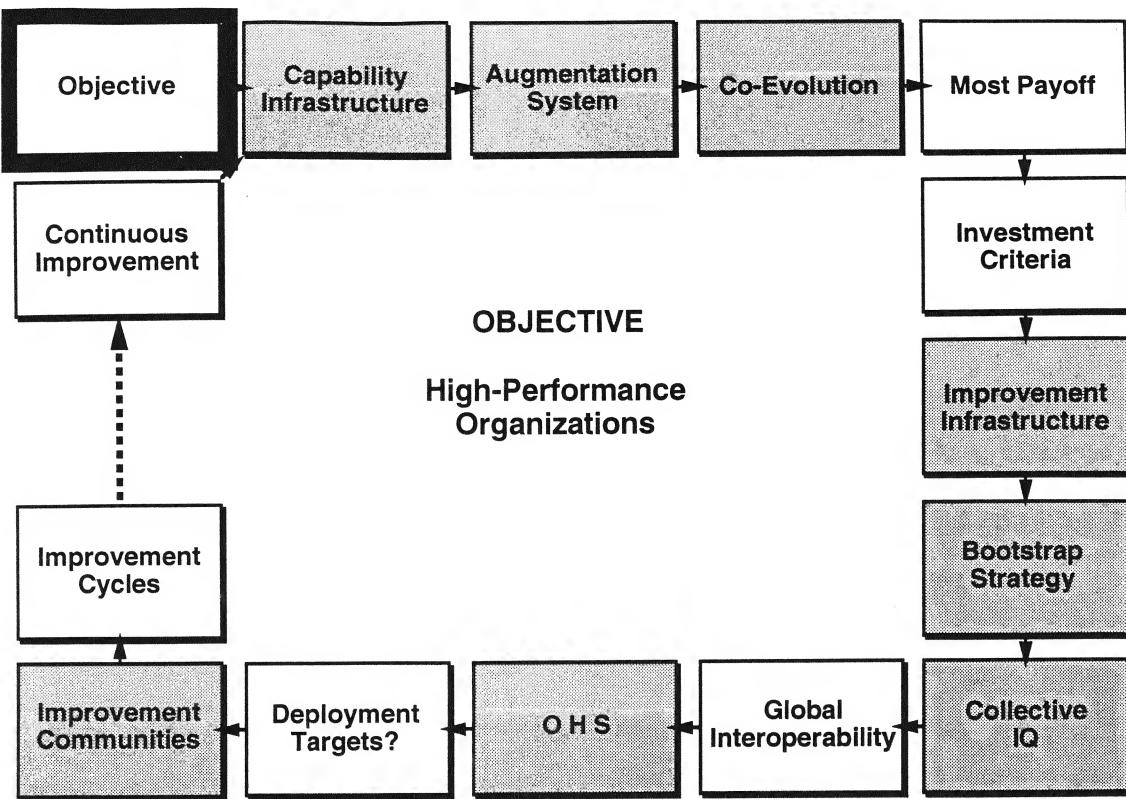


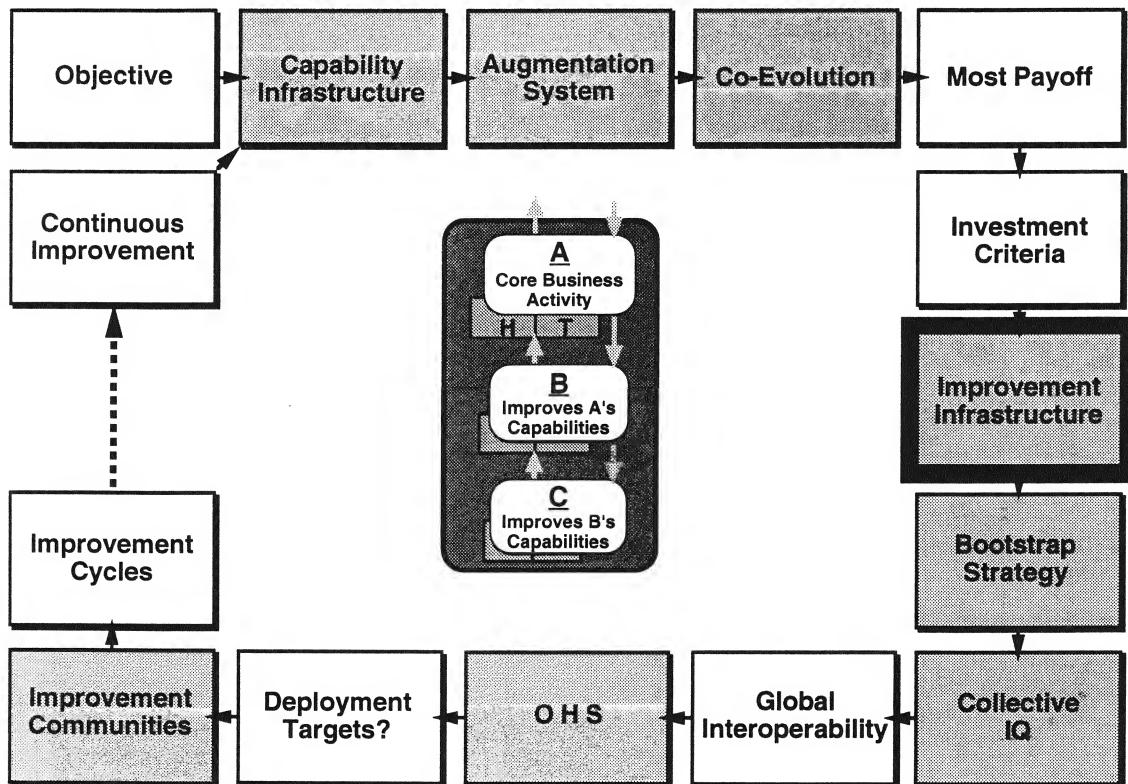
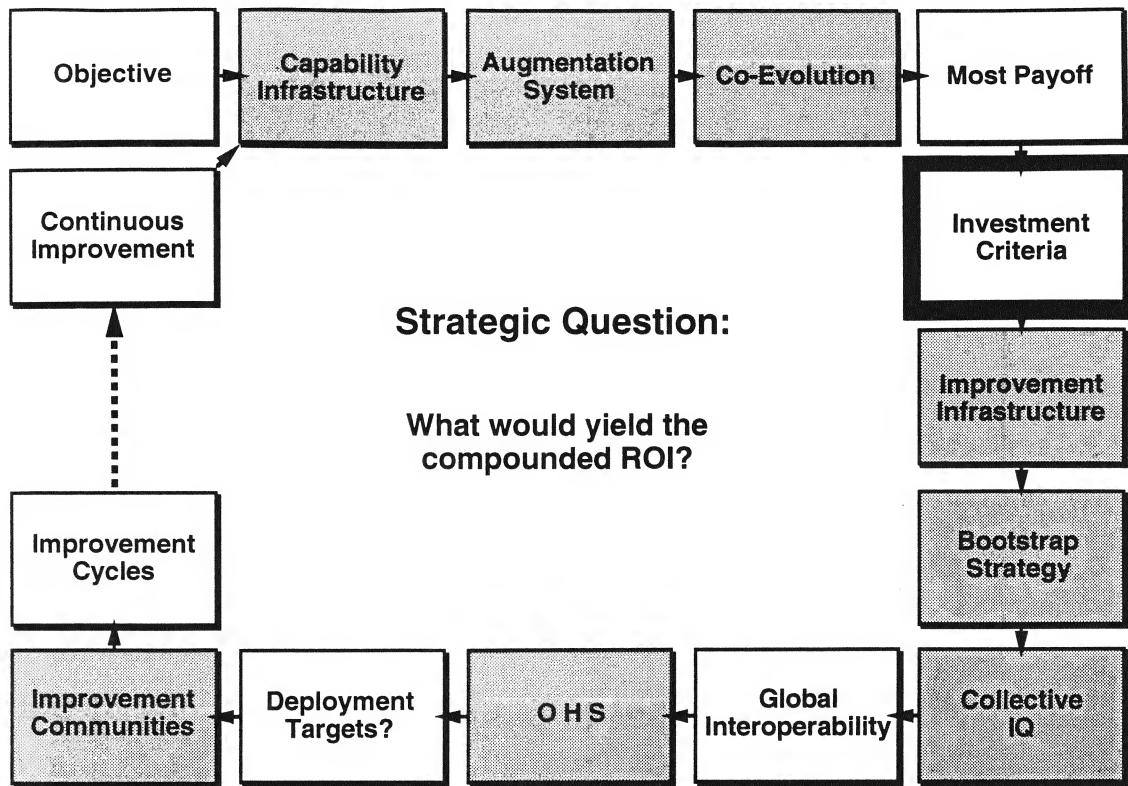


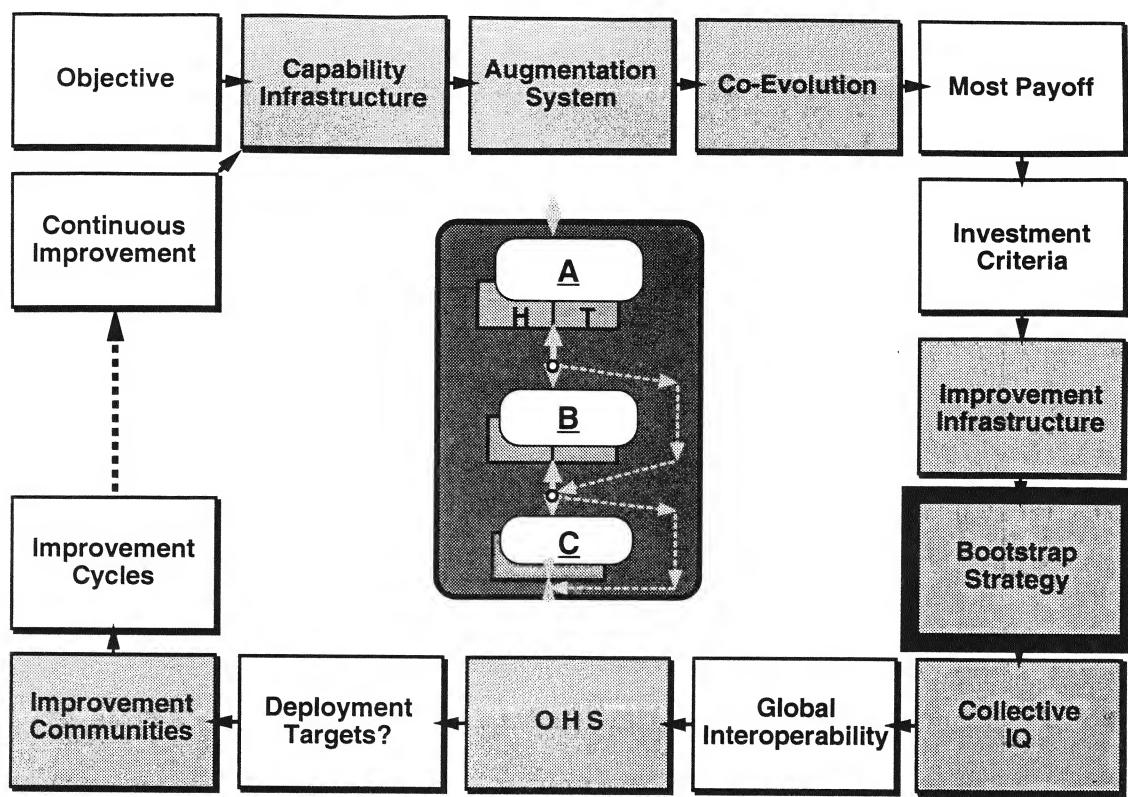


# Notes

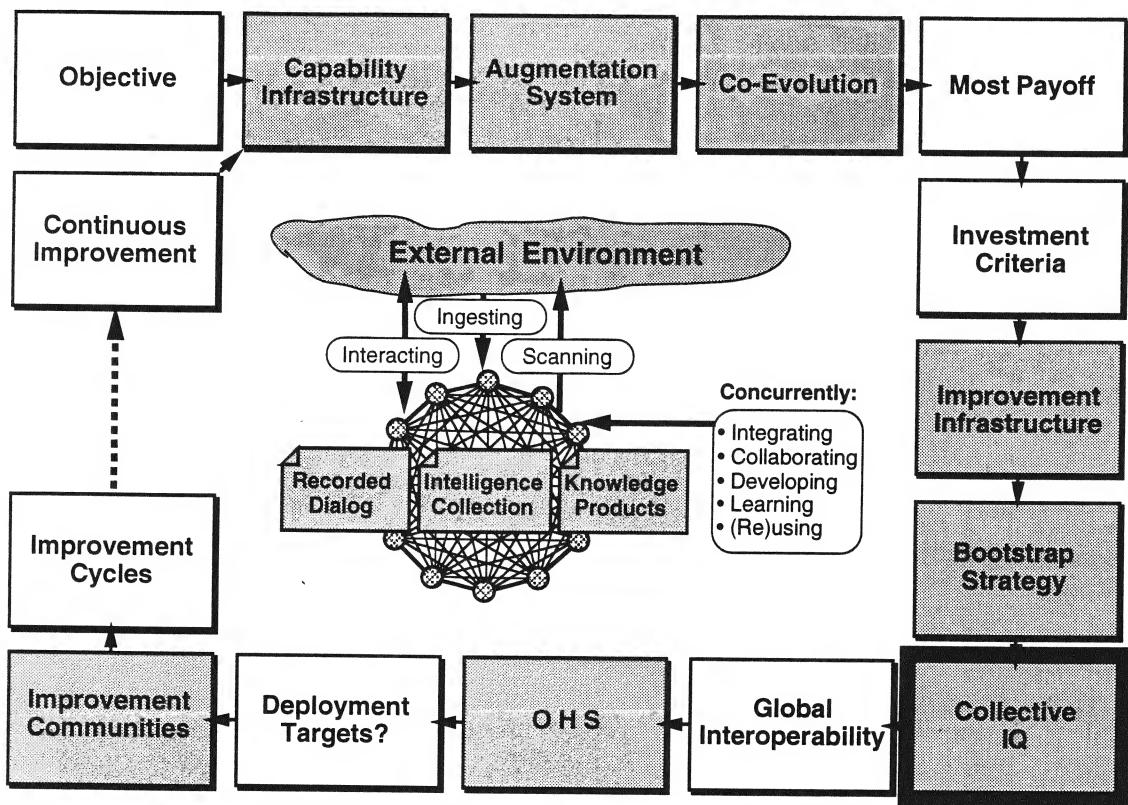
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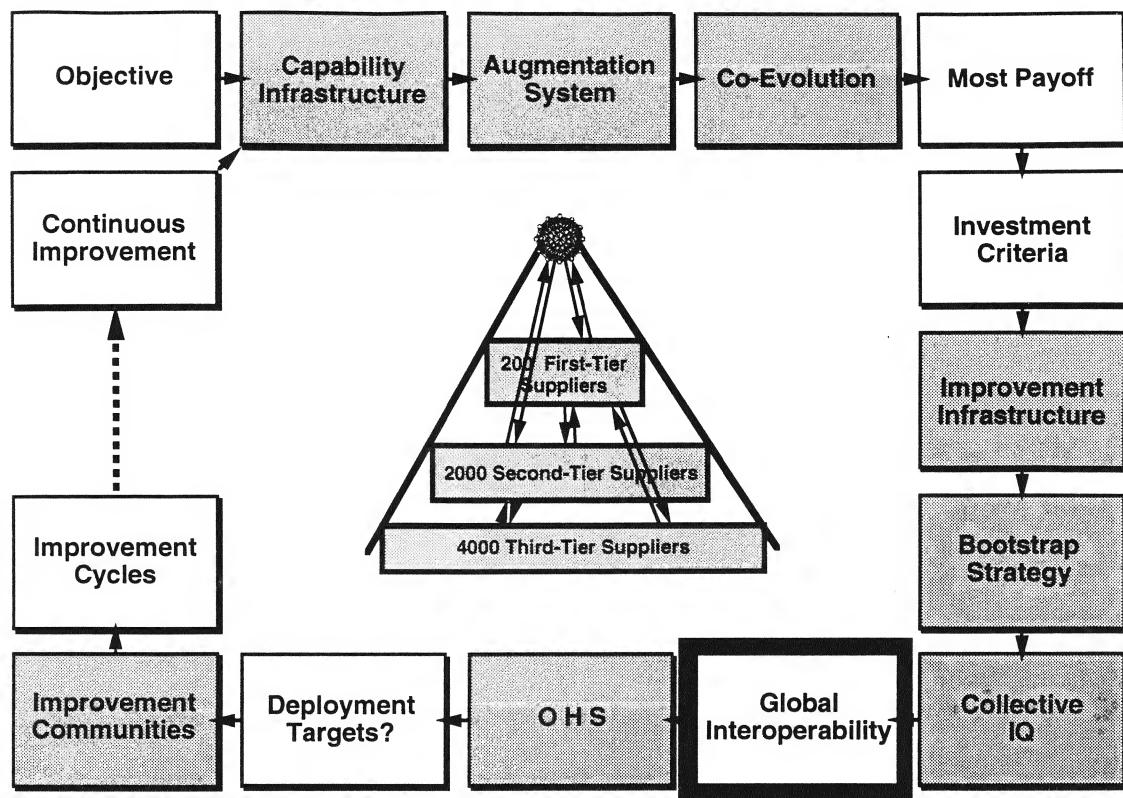




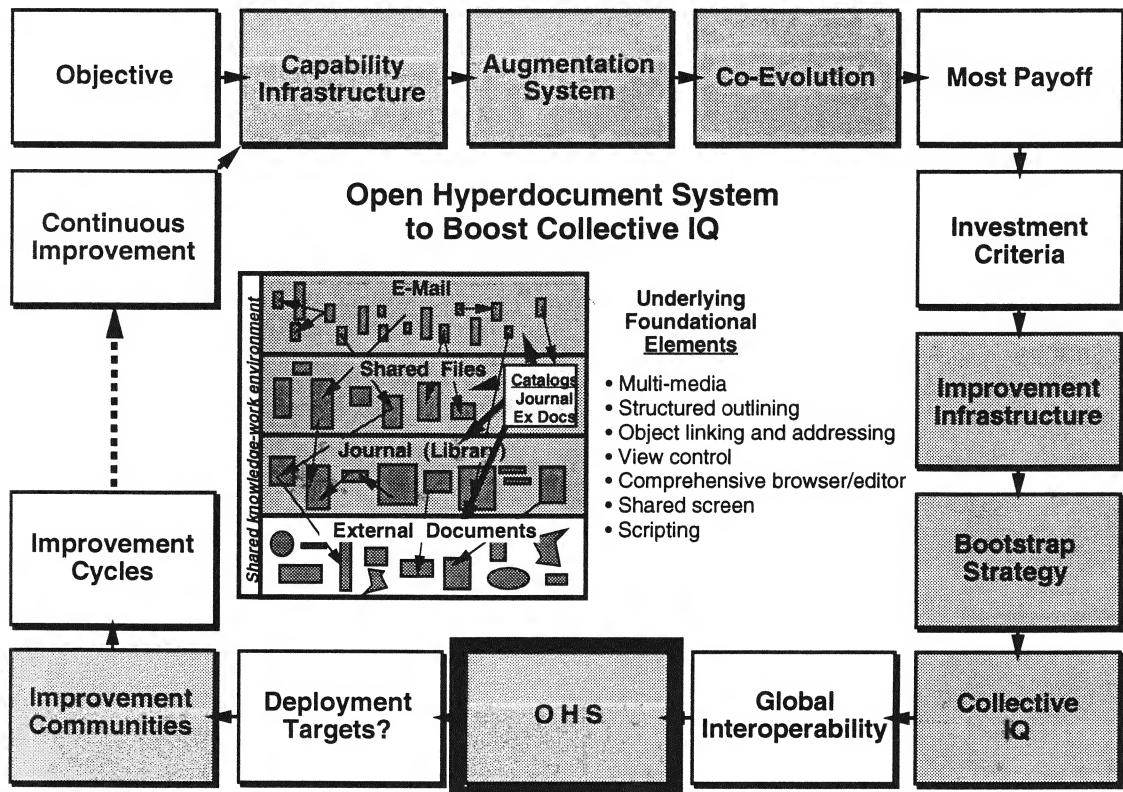
Early targeting of capabilities which boost A,B, and C offers extra bootstrapping leverage (i.e. cross-cutting core competency.)



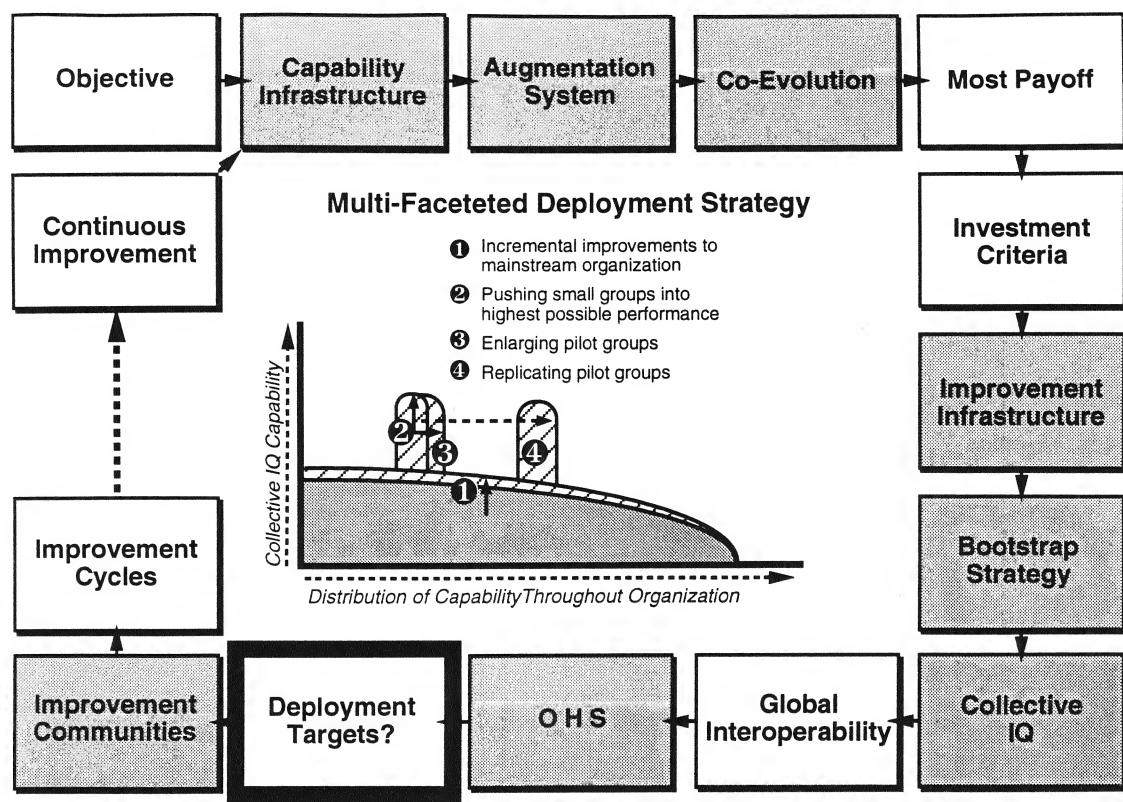
Collective IQ includes collective perception, memory, foresight, reasoning, planning, coordinating resources, responsiveness



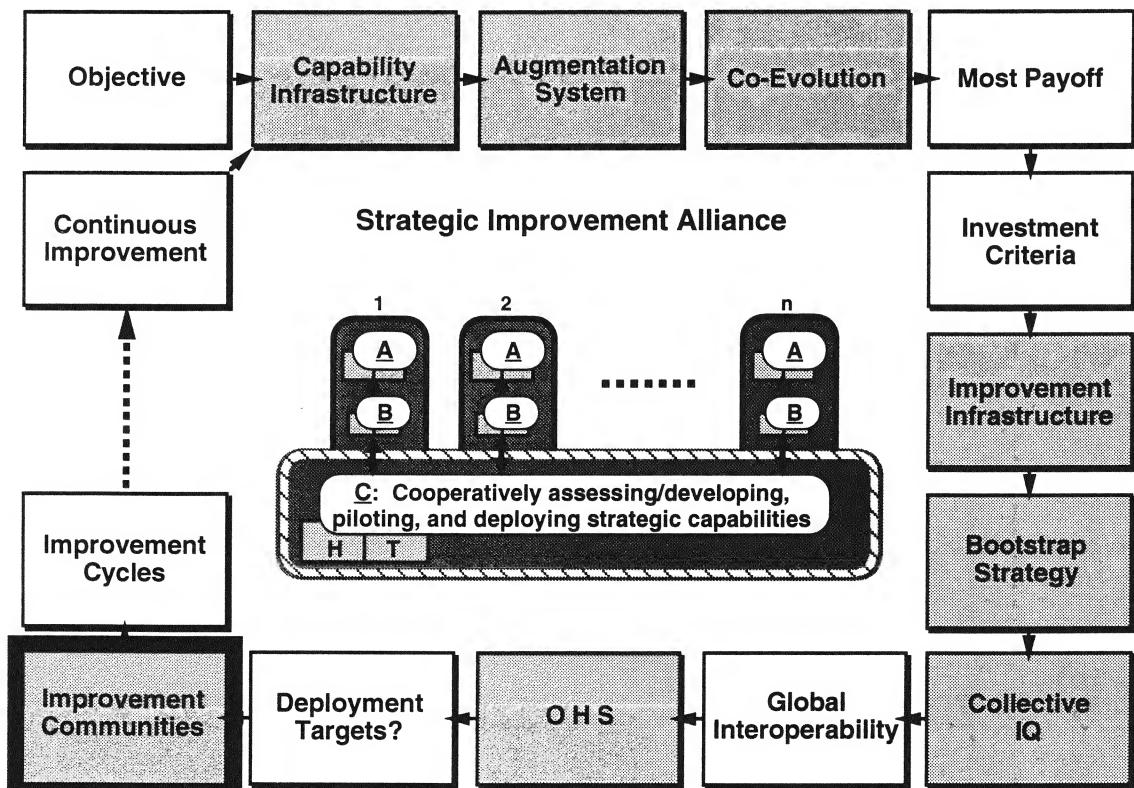
Requirements for interoperability extend the scope of standards



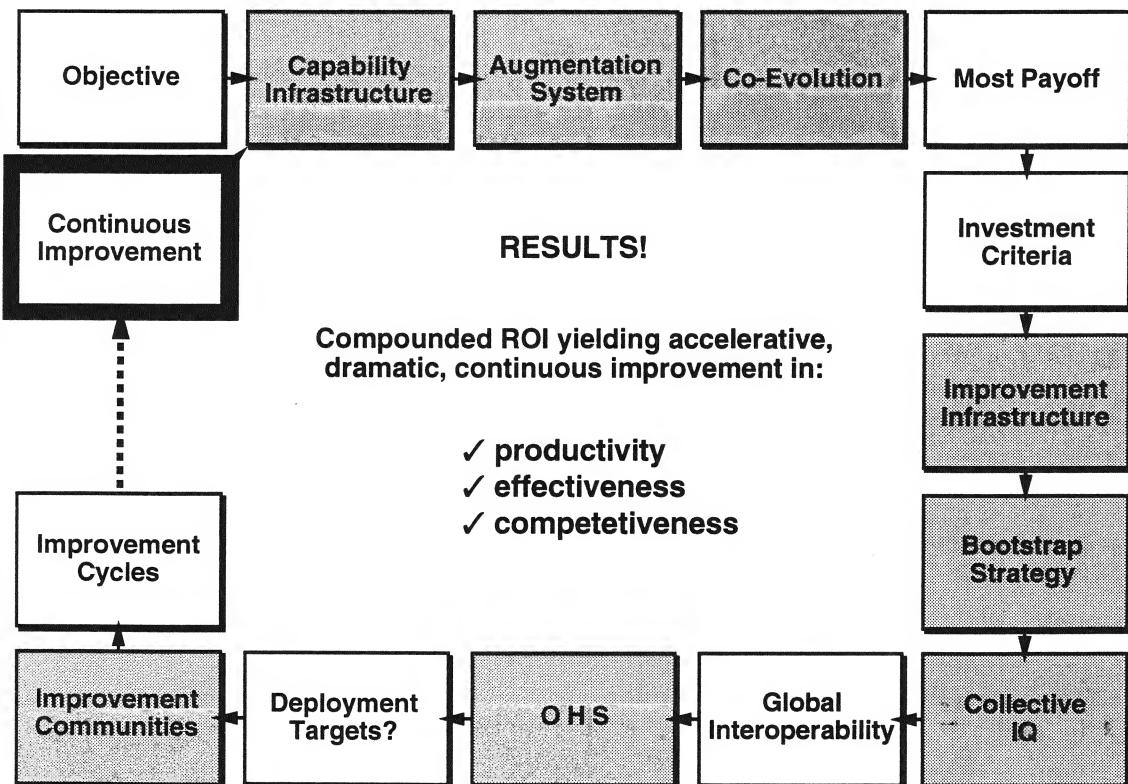
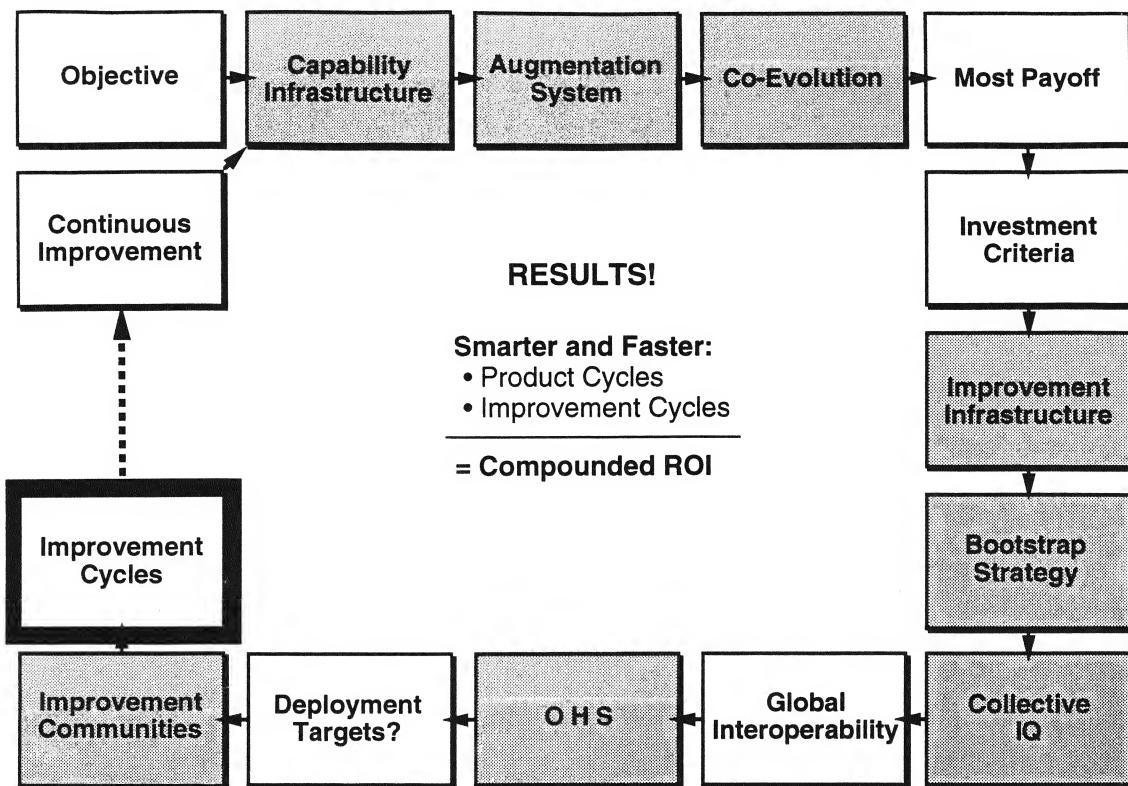
Applications and utilities would plug in to this open infrastructure. Assuming this evolves to satisfy all basic generic knowledge work requirements, applications would become more like utilities



*Most strategic progression: First target is type-2 pilot group involved in C Activity, then enlarge (via type-3), and replicate within selected B teams (via type-4) whose mission is to improve Collective IQ within A (via type-4 and type-1).*



*Organizations cooperating on common requirements, such as boosting Collective IQ, and deploying results within C, B, and A according to the strategic principles outlined above, will forge the most direct, cost-effective evolutionary path*





# Notes

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# Bootstrapping Organizations into the 21st Century

## A Strategic Framework

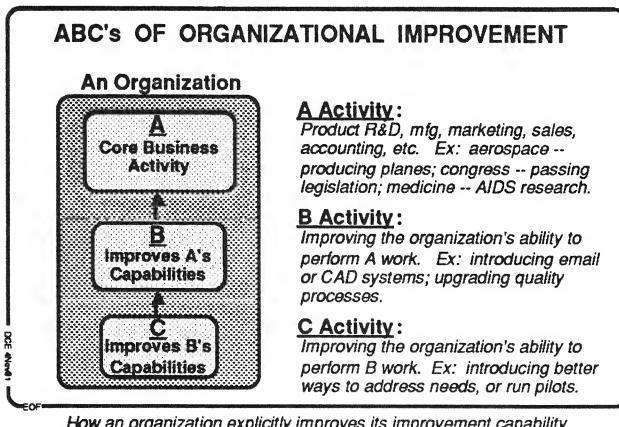
Douglas C. Engelbart  
Bootstrap Institute  
Doc#132803 • Dec 91

Positioning organizations to meet the unprecedented challenges of the 1990's and beyond will require sweeping changes in every facet of organizational life. It will not be a simple matter of replacing our existing work structures, procedures, and technologies. What is required is a *strategy for organizational fitness*, including leveraging limited resources to effect dramatic, rapid, and continuous improvement.

The following outlines a comprehensive strategic framework for *bootstrapping organizations into the 21st century*, and an explicit proposal for launching an exploratory pilot implementation of this strategy.

### ABC's of Organizational Improvement

Given the shifting nature of organizations, the increasingly complex and urgent global market forces, and the virtual bombardment of end users by vendors and consultants, organizations must keep getting *faster and smarter* at identifying and integrating improvements into their every day life. Improving this *improvement capability* should be a key element in every organization's improvement strategy:



As a minimum, organizations must adopt a permanent and highly-coordinated *B Activity*, responsible for continuously identifying and implementing candidate improvements to the core business activity.

But the current means of developing and transferring improvements are not adequate for the scale and rate of change faced today. Organizations need to learn more effective ways of assimilating dramatic improvements on a continuing basis. They need to get better at understanding requirements, surveying, evaluating, selecting, integrating, developing, testing, and applying the improvements. And they need to

*A key to the long-term vitality of an organization -- to get better and better at improving itself.*

get better and better at deploying the improvements into rapidly shifting organizational targets -- identifying suitable pilot groups, planning the training program, running and evaluating the pilot results, learning how much to introduce, how quickly, how to overcome cultural barriers, and how to quickly incorporate lessons learned.

To improve this *B Activity* improvement capability, organizations will need to invest in an explicit ongoing *C Activity*. A key to the long-term vitality and competitive edge for an organization will be to get better and better at improving itself.

### Extra "Bootstrapping" Leverage

Ideally the *C Activity* should focus on improving generic capabilities which boost all three Activities (A, B, and C). For example, a key strategic target early on would be to improve how an organization:

- identifies needs and opportunities;
- plans and deploys solutions;
- incorporates lessons learned.

Since these basic knowledge-work capabilities are central to effective A, B, and C work, improving them would boost both the *job capability* and the *improvement capability* simultaneously, thus providing extra compounded investment leverage, or *bootstrapping* leverage.

### Concurrent Knowledge Work

As complexity and urgency increase, the need for highly effective knowledge-work capabilities will become increasingly urgent. Increasing pressure for reduced product cycle time, and for more and more work to be done concurrently, is forcing unprecedented coordination across project functions and organizational boundaries. Yet most organizations do not have a comprehensive picture of what knowledge work is, and which aspects would be most profitable to improve.

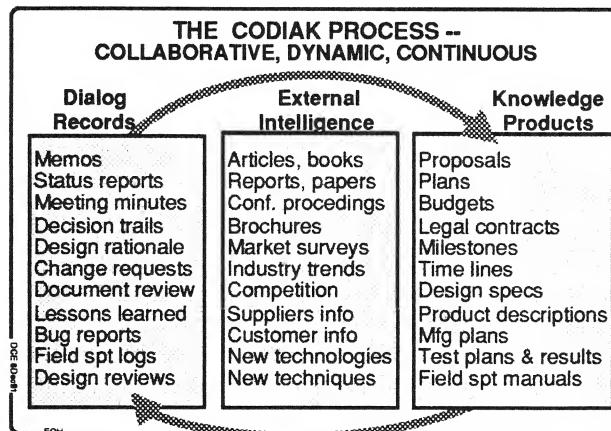
The objective of most knowledge work is to determine and describe what needs to be done, and how and when it will be accomplished -- i.e. to identify needs and opportunities, plan and deploy solutions, and incorporate lessons learned.

**Identifying Needs and Opportunities:** An alert project group, whether classified as an A, B, or C Activity, always keeps a watchful eye on its external environment, actively surveying, ingesting, and interacting with it. The resulting *intelligence* is integrated with other project knowledge on an ongoing basis to identify problems, needs, and opportunities which might require attention or action.

**Planning and Deploying Solutions:** Responding effectively to needs and opportunities involves a high degree of coordination and *dialog* within and across project groups. The resulting plans provide a comprehensive picture of the project at hand -- e.g. new products and services, improvements to existing products and services, or solutions to a specific problem situation. These plans, which are iteratively and collaboratively developed, represent the *knowledge products* of the project team, and constitute a roadmap for implementation and deployment.

**Incorporating Lessons Learned:** The planning process is rarely a one-shot effort. Lessons learned, as well as intelligence and dialog, must be constantly analyzed, digested, and integrated into the planning documents throughout the life cycle of the project.

For lack of a better term, I call this basic knowledge-work process a CODIAK process, for the COncurrent Development, Integration, and Application of Knowledge. The resulting operational knowledge base, consisting of intelligence, dialog records, and knowledge products, is continuously updated, used, and re-used by many players, concurrently and over time:



CODIAK: COncurrent Development, Integration, & Application of Knowledge.

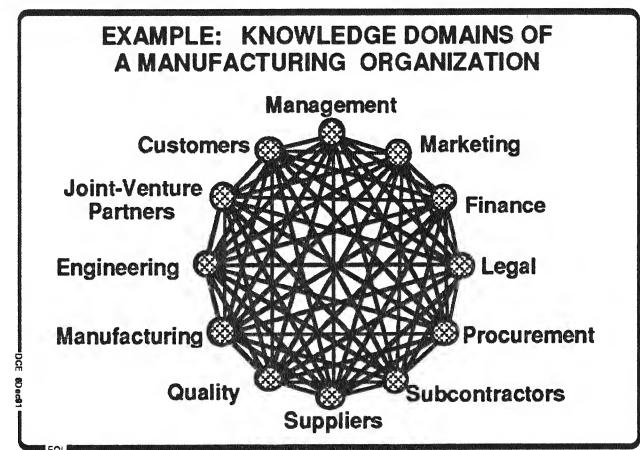
This knowledge base represents a valuable corporate asset. And yet, many of its crucial elements, such as decision trails and intelligence collections, are generally *not* recorded. Even minor inadequacies in the CODIAK process can be extremely costly in terms of:

- slip-ups in version control;
- lapses in project "memory" (e.g. design rationale);
- delayed access to important intelligence;
- non-optimal collaboration on design decisions.

*This knowledge process is the driving force of the organization, and the resulting body of knowledge represents a valuable corporate asset.*

## The Concurrent, Integrated Enterprise

Almost every effort in the organization is immersed in, or impacted by, an ongoing CODIAK process. And each organizational unit's knowledge process and knowledge products -- whether individual, project team, functional unit, program, department, division, task force -- are part of a larger effort within and even outside of the organization:



Enterprise integration: Interoperability within & across knowledge domains

This nested web of concurrent knowledge-work is especially evident in complex R&D and manufacturing environments, where close coordination via concurrent engineering, or total quality management, is increasingly critical. And in the case of joint ventures, each knowledge domain must integrate its CODIAK work within, and also across, organizations.

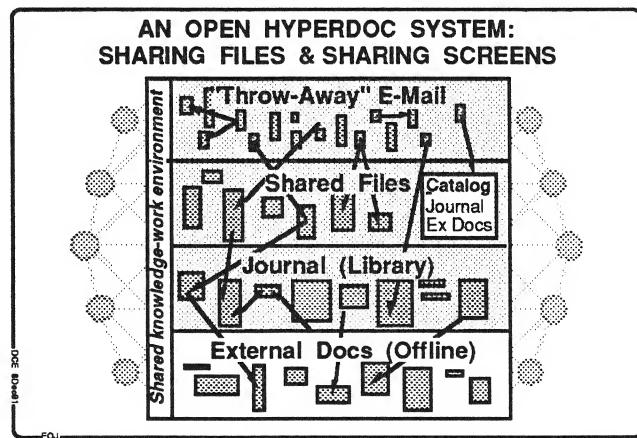
The CODIAK process is the driving force of the organization, providing direction and momentum for new or renewed organizational efforts. Giving knowledge workers new capabilities for coordinating their work concurrently, with instant access to the correct document, and all the supporting intelligence and dialog trails which led to key decisions, could dramatically reduce product-cycle time and improve first-time quality. Significantly improved CODIAK capabilities, applied within the C, B, and A Activities of an organization, offer powerful bootstrapping leverage for improving overall effectiveness, productivity, and fitness.

## An Open Hyperdocument System (OHS)

As more and more of the CODIAK process work moves *online*, and more of the work is done concurrently using a hodgepodge of workstations, networks, application packages, and utilities, organizations will be faced with a whole new set of challenges for coordinating the enterprise knowledge work.

A strategic solution to these challenges begins with a *hyperdocument system*. The *hyperdocument* refers to multimedia files which support many object types, including hypertext links, hyperdocument e-mail, and online hyperdocument publishing (library) with automated cataloging and version control. Links should be easily created, human-readable, and printable. Files should have structure, and objects should be independently addressable within a file, with zooming in and out and other on-the-fly custom views. Personal signature encryption and suitable privacy provisions should also be supported.

A hyperdocument system should enable flexible collaborative development, integration, application, study, and re-use of CODIAK knowledge *online*:

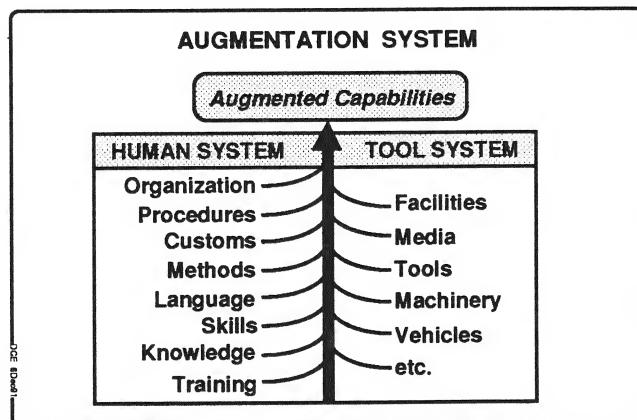


Ultimately, the hyperdocument system will need to be an *open hyperdocument system* (OHS), allowing for an integrated "seamless" multi-vendor architecture where distributed diverse knowledge workers can share hyperdocument files, and share screens, regardless of each worker's particular hardware/software configuration.

This interoperability must extend across departments and across organizations to include customers, suppliers, and joint-venture partners. Furthermore, within the integrated enterprise of tomorrow, standard provisions must exist for links between OHS documents and objects within other enterprise data forms (e.g. data bases, CAD models). An OHS should provide totally interoperable CODIAK support for a truly concurrent, integrated enterprise.

## The Co-Evolution Approach

An OHS would go a long way toward providing much needed improvements to the CODIAK process. However, most capabilities are improved, or *augmented*, by many interdependent technical and non-technical elements, of which tools make up only a small part:



Augmentation: Continuous co-evolution of human-tool capabilities.

Until recently, we got by with improving selected elements of the Augmentation System in isolation, assuming that the other elements would eventually adapt "on their own".

But with the recent computer revolution, many organizations' Augmentation Systems are now heavily weighted with point-solution technology, seriously overpowering the human-system elements. Tools are being introduced to automate methods that evolved around now-obsolete tools, and vice versa. Many tools are not being harnessed effectively for lack of appropriate, well-evolved methods.

As the complexity and urgency of our improvement programs increase, this tactically-limited trend will prove to be very costly. Until we significantly stretch our perception of the scale and pervasiveness of change-opportunities in the human-system side of the equation, the organizational stresses from unbalanced Augmentation Systems will worsen, and the truly significant improvements in organizational capability will be forestalled.

The OHS requirements described above are based on 20 years of experience with an early OHS prototype used in large pilot trials in government and aerospace organizations. These requirements are recommended as a baseline starting point only. There is *much* more to be learned about the rigorous use of an OHS in a wide-area, distributed CODIAK process. The human-system elements -- all the methods, procedures, conventions, skills, etc. -- must be highly developed, in close association with the continuing evolution of OHS requirements.

## Exploratory Pilots

To intensify and accelerate the human-tool co-evolution process, intensive pilot environments must be established by the C and B Activities. The C Activity should operate as the first pilot *outpost* of the organization, evolving the advanced methods and system prototypes to support its own intensive CODIAK process, and paving the way for subsequent pilot operations. Flexibly evolving OHS research prototypes will be required to support the advanced pilot exploration in a wide variety of application areas (e.g. CASE, concurrent engineering, total quality, CSCW). The resulting experience will feed the requirements definition for future prototypes, for products and services, and for the standards that will ultimately be required to support a truly integrated and interoperable OHS architecture. The experience will also serve to maximize the relevance, applicability, and transferability of the resulting products and services, rendering increased cost-effectiveness for end-user organizations and vendors alike.

Now, who will be responsible for this exploratory work? Vendors? End-user organizations? Universities? Government?

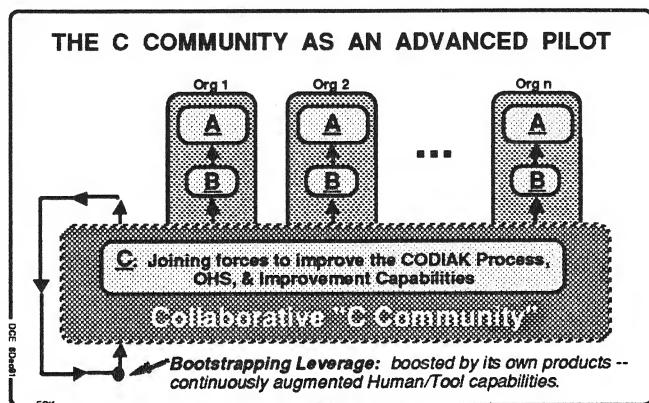
## C Activities Joining Forces

Ultimately, C Activities from a wide range of enterprises will need to join forces in a cooperative *C Community* to collaborate on common activities. This is feasible because most C Activity is generic, not proprietary. It is highly desirable because creating a vibrant pilot environment to support this work will be very costly. By pooling resources, members can spread the risk and spend less to get more -- including attracting resources that would otherwise not be available -- thus freeing up more internal resources to further invest in their proprietary B and A Activities.

Joining forces is also *necessary* for dealing appropriately with the increasingly complex interoperability requirements between enterprises. For instance, understanding the requirements for an OHS, developing a procurement approach for OHS prototypes to support planned pilot usage among Community Mem-

bers, coordinating the planning and operation of such pilots, and integrating the lessons learned seems the most promising way to yield the desired results. And coordinating the standards requirements for interfacing or integrating applications software and utilities can only be accomplished by extensive cooperation among user organizations and vendors.

Such a *Bootstrap Initiative* would provide a common focus for user organizations, vendors, consultants, government agencies, and universities. Operating as an advanced pilot, or living prototype of its work, its results would be directly transferable to member organizations:



A *Bootstrap Initiative* offers the most direct, high-leverage, cost-effective path for bootstrapping organizations. But individual organizations *can* get started on their own, even before an Initiative is formally launched. They can begin by forming an explicit C Activity, headed by a responsible high-level executive, and staffed and advised by stakeholders from representative B Activities, to integrate the bootstrap strategy with their own strategic planning efforts. They can start planning for selected exploratory pilots, using off-the-shelf hyperdocument systems, and begin to test out the concepts and strategies described here.

The sooner organizations launch on a strategic path toward high-performance organizational fitness, the sooner the benefits can be achieved. Where does *your* organization stand?

*"I would encourage you to take part in the Bootstrap Initiative."*

(Patricia Seybold, PS, April '90)

**About the Author.** Dr. Douglas C. Engelbart has a 30-year track record as a visionary and pioneer of integrated information systems and organizational augmentation. Well-known contributions include the mouse, display editing, windows, outline/idea processing, hypermedia, and groupware, with early prototypes in full operation under the NLS/AUGMENT system by 1968. In the last decade, thousands of industrial knowledge workers have benefited from its unique team support capabilities, more recently in internal pilots within McDonnell Douglas. Dr. Engelbart is currently Director of the Bootstrap Institute in Palo Alto, CA, dedicated to launching the Bootstrap Initiative. He is also an associate at Stanford University's Center for Design Research, where he runs the 3-day management seminar "Bootstrapping Organizations into the 21st Century". Engelbart has received several awards for outstanding lifetime achievement and ingenuity.



# Notes

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## TOWARD HIGH-PERFORMANCE ORGANIZATIONS: A STRATEGIC ROLE FOR GROUPWARE

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### ABSTRACT

Achieving tomorrow's high-performance organizations will involve massive changes throughout their capability infrastructures. The complexity of implementing these changes will be daunting, and deserves a strategic approach. Groupware will support important, special new knowledge capabilities in these infrastructures, and also can play a key role in an evolutionary strategy.

### 1 INTRODUCTION

#### 1.1 Shared Visions and the "Groupware Community"

Groupware to me, personally, is a strategic means to an important end: creating truly high-performance human organizations. My pursuit began in the '50s, aiming to make our organizations and institutions better able to handle complexity and urgency. By 1962 I had evolved a basic conceptual framework for pursuing that goal (Ref-1 and Ref-2). I have essentially lived and worked within that framework ever since, steadily evolving and enriching it via many relevant experiences.

It is becoming relatively common of late, in the increasing flow of literature about organizational improvement, to highlight the need for the members of an organization to have a shared vision of where and how the organization is moving, in its marketplace and in its internal evolution. I assume that the same principle should be applicable to a looser organizational unit, in this case, to the community consisting of organizations and researchers interested in the overlapping domains of organizational improvement and "groupware," and including the information-system marketplace whose business is providing products and services to end-user organizations.

From my experience, the nature of this shared vision will be the single most important factor in how directly and how well the digital-technology marketplace will indeed support significantly higher organizational capability — which I assume is our basic objective in the evolution of groupware.

My own vision about pursuing high-performance organizations has matured over the years into a quite comprehensive, multi-faceted, strategic framework. It may seem a bit radical in nature, but my continuing hope is that it will be merged into such a shared community vision.

The full purpose of our Bootstrap Institute is to promote constructive dialog with critical stakeholders in the community about this “bootstrap strategy,” to facilitate its trial adoption, and to further the strategy’s own “continuous improvement.”

In this paper I summarize the key elements of this strategic framework and highlight the role that would be played by the “groupware community.” In Ref-3 is an explicit historical treatment that provides a good deal of background on framework development up to 1986. Also, Ref-4 gives a relatively balanced description of our associated groupware and application developments with an underlying framework treatment.

## 1.2 Capability Infrastructure and its Augmentation System

Any high-level capability needed by an organization rests atop a broad and deep *capability infrastructure*, comprised of many layers of composite capabilities, each depending upon the integration of lower-level capabilities. At the lower levels lie two categories of capabilities: Human-Based and Tool-Based. The functional capabilities of groupware fit into the latter category, along with a wide variety of facilities, artifacts, and other tools.

In pursuit of higher organizational performance, this infrastructure is the obvious focus of attention. Then it is a matter of establishing system and goal perspectives to determine how much of this infrastructure to include as serious candidates for change, and how radical a change to contemplate. I arrived at a singularly global perspective from the following considerations.

Figure 1 shows the result of a great deal of thought about how over the centuries our cultures have evolved rich systems of things that, when humans are conditioned and trained to employ them, will *augment* their basic, genetically endowed capabilities so that they, and their organizations, can exercise capabilities of much higher nature than would otherwise be possible. For lack of a ready-made term, I named this our *Augmentation System*, and found it valuable to partition it into the two parts as shown — a Human System and a Tool System. I have developed many things from this model that have proved useful and valid over the years — including essentially everything I’ve developed in the groupware arena (tools, concepts, strategies).

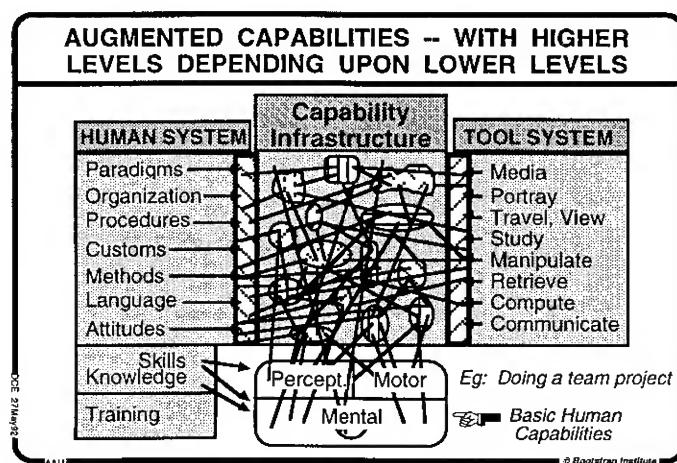


Figure 1

A bit of thinking about this model brought me the realization that we are far short of being able to do a one-pass re-design of any major portion of this capability infrastructure — if only because of their pervasive, underlying dependence upon human processes.

And as we pursue significant capability improvement, we need to appreciate that we will be trying to affect the evolution of a very large and complex system that has a life and evolutionary dynamic of its own. Concurrent evolution of many parts of the system will be going on anyway (as it has for centuries). We will have to go along with that situation, and pursue our improvement objectives via facilitation and guidance of these evolutionary processes. Therefore, we should become especially oriented to pursuing improvement as a multi-element, *co-evolution* process. In particular, we need to give explicit attention to the co-evolution of the Tool System and the Human System.

And, along with these foregoing perceptions, another factor popped into the scene to create a very significant effect on my emergent framework.

### 1.3 The Relevant Implications of Radical Scale Change

Some years earlier, I had studied the issues and prospects associated with extreme miniaturization of functional devices, towards assessing the likelihood of digital equipment becoming extremely small, fast and cheap. I was personally motivated because I would have to be relatively confident of very significant progress in that regard in order to commit a career towards facilitating widespread computer augmentation.

I learned enough to convince myself that, with the expected high industrial and military demand toward digital technology, the achievable limits on micro scalability were far beyond what would be enough to warrant my particular pursuits. And in the process, looking into references dealing with dimensional scale in living things, I became aware of a very important general principle: if the scale is changed for critical parameters within a complex system, the effects will at first appear as quantitative changes in general appearance, but after a certain point, further scale change in these parameters will yield ever-more striking *qualitative* changes in the system.

For example: The appropriate design for a five-foot creature is not that much different from that for a six-foot creature. But the design for either of these would be totally inappropriate for a one-inch creature, or for a thirty-foot creature. A mosquito as big as a human couldn't stand, fly or breathe. A human the size of a mosquito would be badly equipped for basic mobility, and for instance would not be able to drink from a puddle without struggling to break the surface tension, and then if his face were wetted, would very likely get pulled under and be unable to escape drowning.

The lesson: Expect surprising qualitative changes in structural assemblage and functional performance when a complex system adapts effectively to drastic changes in critical parameters.

I could only assume that the same is very likely to be true for the complex Augmentation System that supports an organization's capability infrastructure. Here, the radical change in the scale of Tool System capability — in speed, function, capacity, presentation quality, transmission, etc. of emergent digital technology — greatly transcends any other perturbation in system parameters that our organizations have ever needed to adapt to in so short a time as a few decades.

Much more could be said about the scaling issue that is relevant to the general theme of organizational change. Sufficient here to say that these thoughts drove me definitely to

view as global and massive both the opportunity and the challenge that we humans were facing with respect to increasing the performance level of the organizations and institutions upon which mankind's continuing existence depends.

#### **1.4 The Underlying Importance of Paradigms**

In the ensuing thirty years since the model of Figure 1 first evolved, I have become ever more convinced that human organizations can be transformed into much higher levels of capability. These digital technologies, which we have barely learned to harness, represent a totally new type of nervous system around which there can evolve new, higher forms of social organisms.

In the face of mounting evidence that our organizations and institutions can not cope adequately with the increasing complexity and urgency of our society's problems, it seems highly motivating to explore every avenue that offers reasonable probability of improving their capability to cope.

Those were my thoughts thirty years ago; they seem even more germane today. The technologies have been demonstrated, and our organizations are aligning toward internal improvement. What seems still to be lacking is an appropriate general perception that:

- (a) huge changes are likely, and really significant improvements are possible;
- (b) surprising qualitative changes may be involved in acquiring higher performance; and
- (c) there might actually be an effective, pragmatic strategy for pursuing those improvements.

In developing a basic, scalable strategy, the above issues of perception are important enough to warrant being explicitly factored into it. In other words, the strategy should provide for the need of significant shifts in our perception of our likely and possible futures.

Perceptions, shared visions, paradigms — their evolution is *critical*, yet they receive little or no direct developmental attention. The slow, un-shepherded paradigm drifting of the past isn't an adequate process for times when deeper global changes are occurring than ever-before accommodated by such massive social bodies. And the rates of such change are more likely to increase than to diminish.

I interject such thoughts here because I actually believe that what can be produced by the groupware community can make a very large difference (in a proper strategic framework) to our capability for coping with large, complex problems. The ability to acquire this new capability is heavily dependent upon evolving an appropriate paradigm, which result in itself represents the type of complex challenge that our institutions need to become more capable of handling.

This leads to an assumption that an important factor to hope for, in an early stage of the future paradigms possessed by key players in this transformation of our organizations, is the perception of importance and a can-do attitude about consciously cultivating appropriate evolutionary trends and change rates in our future paradigms. Shifting our paradigm about paradigms.

What role will *you* play?

## 2 IMPROVING THE IMPROVEMENT PROCESS

The next step in developing an explicit strategic framework was generated from the conceptual content of Figure 1 by asking what sort of investment principles would make sense. I hoped to solicit R&D money and wondered how we might get the best return on those funds in facing this very large, unstructured problem. I also was prepared to invest essentially the rest of my professional career: how should I invest that time to get best net progress? And what basic guidelines should be adopted for launching (bare handed, so to speak) such a program?

The only serious approach that I could imagine, towards really significant improvement, would be a long-term, pragmatically guided, whole-system evolution. I was addressing a very complex system, and the challenge would be further complicated by the fact that the subject organizations would have to keep functioning at better than survival level while undergoing large, systemic changes.

So the image depicted in Figure 2 emerged from realizing that the capability of an organization to improve itself would have to become much more prominent and effective. It then seemed natural to consider a strategy wherein the earliest improvement efforts might be concentrated upon improving this capability (i.e., to improve the organization's improvement capability).

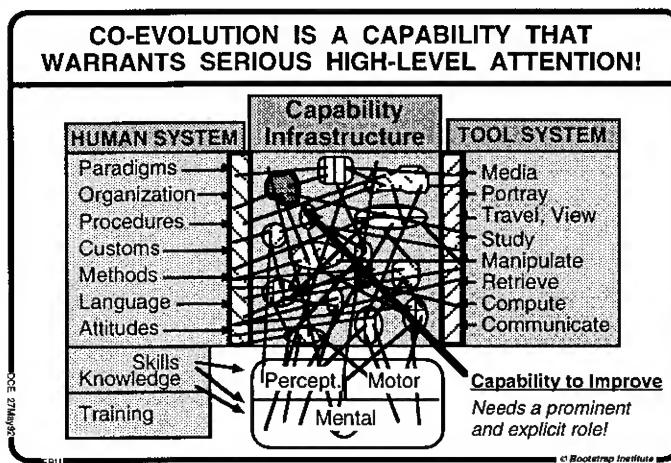


Figure 2

## 3 THE ABC MODEL OF ORGANIZATIONAL IMPROVEMENT

In doing some further thinking about improvement activities and the capabilities that support them, I found it useful to extract from Figure 2 a simpler abstraction dealing with organizational improvement, as in Figure 3. Here we separate the two types of activities, *A* and *B*, and show that the capability for each type of work is supported by its respective Augmentation System (comprised of Human and Tool systems).

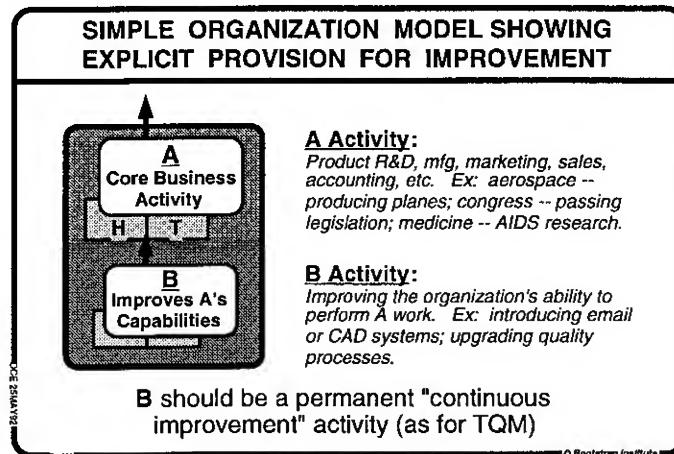


Figure 3

Given this model, we can now consider the prospects of improving the organization's improvement capability, as discussed earlier in Figure 2, as *improving the capability of the B Activity*. And for such a critical pursuit to be effective requires yet another explicit organizational activity, depicted in Figure 4 as the organization's C Activity. Executive efforts to assess and improve B-Activity funding, staffing, and high-level approach would qualify as a C Activity. C Activities would also include introducing new knowledge and skills into the B Activity, providing better means for participatory interaction with its A-Activity clients, or improving how pilot operations are managed.

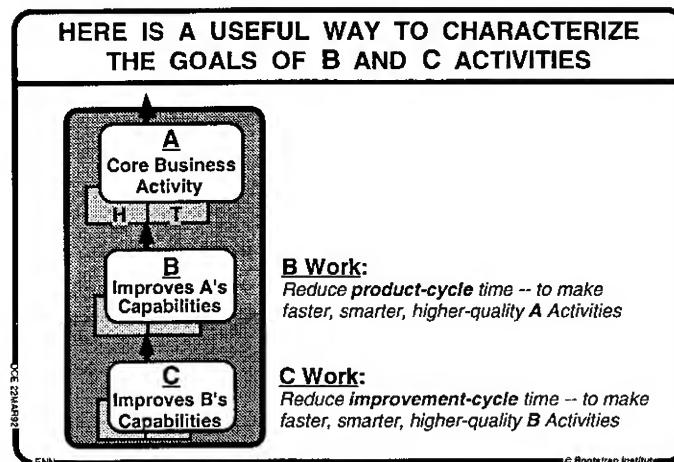


Figure 4

#### 4 LOOKING FOR A MULTI-PAYOUT CAPABILITY CLUSTER

In considering the infrastructure elements that support this higher-level, self-improvement B Capability, I realized that many of its important subordinate capabilities are also actively employed by many of the higher-level A Capabilities that are important to the basic operations of the organization. For example, identifying needs and opportunities, designing and deploying solutions, and integrating lessons learned. This led to the following rhetorical question:

*Is there a set of basic capabilities whose improvement would significantly enhance both the higher-level operational A Capabilities and this self-improvement B Capability?*

The answer was a clear "Yes!" A core set of knowledge-related capabilities rapidly emerged as the prime candidate.

An investment that boosts the A Capability provides a one-shot boost. An investment that boosts the B Capability boosts the subsequent rate by which the A Capability increases. And an investment that boosts the C Capability boosts the rate at which the rate of improvement can increase. (To be slightly mathematical, investing in B and C boosts respectively the first and second derivative of the improvement curve — single and double compounding, if you wish.)

We are assuming here that selected products of the two capability-improvement activities (B and C) can be utilized not only to boost the capabilities of their client activities, but can also to a significant extent be harnessed within their own activities to boost their subsequent capability. This is depicted in Figure 5 by the "feedback" paths.

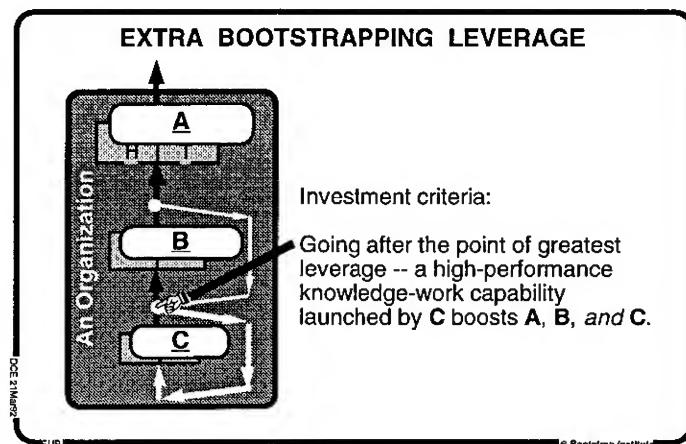


Figure 5

This was where the term *bootstrapping* became welded into my continuing professional framework. It turns out that there are many choices that we will face where balanced consideration of the bootstrapping possibilities can make a difference. I place much confidence in the potential payoff from thoughtful application of the principles that have evolved from such thinking.

## 5 THE CODIAK PROCESS CLUSTER: BEST STRATEGIC APPLICATION CANDIDATE

Over the years I have tried various ways to label and characterize the above-mentioned key knowledge capabilities. For lack of an established term, I have settled on an acronym that embraces the main concepts of this cluster of high-leverage capabilities — CODIAK:

*The concurrent development, integration and application of knowledge.*

As complexity and urgency increase, the need for highly effective CODIAK capabilities will become increasingly urgent. Increased pressure for reduced product cycle time, and for more and more work to be done concurrently, is forcing unprecedented coordination across project functions and organizational boundaries. Yet most organizations do not have a comprehensive picture of what knowledge work is, and of which aspects would be most profitable to improve.

The CODIAK capability is not only the basic machinery that propels our organizations, it also provides the key capabilities for their steering, navigating and self repair. And the body

of applicable knowledge developed represents a critically valuable *asset*. The CODIAK capability is crucial in most A Activities across the organization, whether in strategic planning, marketing, R&D, production, customer support, or operations. It is also crucial in the B and C Activities, whether identifying needs and opportunities, designing and deploying solutions, or incorporating lessons learned — which of course is also used in key A-Activity work. As such, the CODIAK capability should be considered a core business competency in the organization's capability infrastructure, and is an ideal candidate for early improvement to achieve the extra bootstrapping leverage discussed above in Figure 5.

For best exposure to full CODIAK issues, it helps to consider heavy knowledge-intensive activities such as a large, complex project. Figure 6 represents the high-level core of such a CODIAK process. In the center is a basic organizational unit, representing the interactive knowledge domains of a single individual, or of individuals or groups within a project team, department, functional unit, division, task force, committee, whole organization, community, or association (any of which might be inter- or intra- organizational).

Each organizational unit is continuously analyzing, digesting, integrating, collaborating, developing, applying, and re-using its knowledge, much of which is ingested from its external environment (which could be outside of, or within, the same organization).

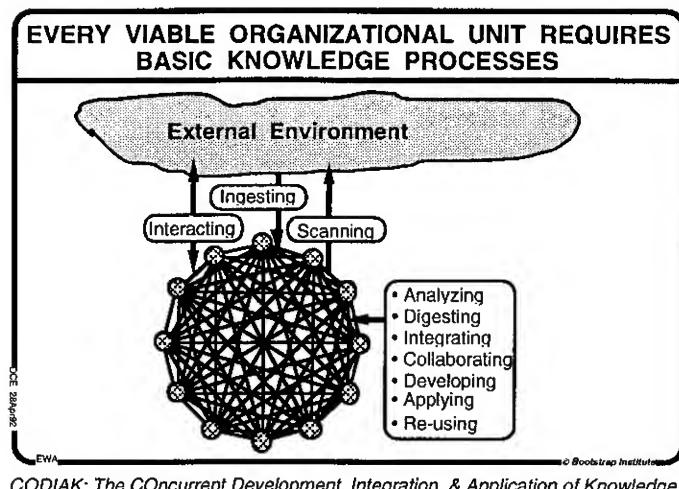


Figure 6

A result of this continuous knowledge process is a dynamically evolving knowledge base as shown in Figure 7 below, consisting of three primary knowledge domains: intelligence, dialog records, and knowledge products (in this example, the design and support documents for a complex product).

**Intelligence Collection:** An alert project group, whether classified as an A, B, or C Activity, always keeps a watchful eye on its external environment, actively surveying, ingesting, and interacting with it. The resulting *intelligence* is integrated with other project knowledge on an ongoing basis to identify problems, needs, and opportunities which might require attention or action.

**Dialog Records:** Responding effectively to needs and opportunities involves a high degree of coordination and *dialog* within and across project groups. This dialog, along with resulting decisions, is integrated with other project knowledge on a continuing basis.

**Knowledge Product:** The resulting plans provide a comprehensive picture of the project at hand, including proposals, specifications, descriptions, work breakdown structures, mile-

stones, time lines, staffing, facility requirements, budgets, and so on. These documents, which are iteratively and collaboratively developed, represent the *knowledge products* of the project team, and constitute both the current project status and a roadmap for implementation and deployment. The CODIAK process is rarely a one-shot effort. Lessons learned, as well as intelligence and dialog, must be constantly analyzed, digested, and integrated into the knowledge products throughout the life cycle of the project.

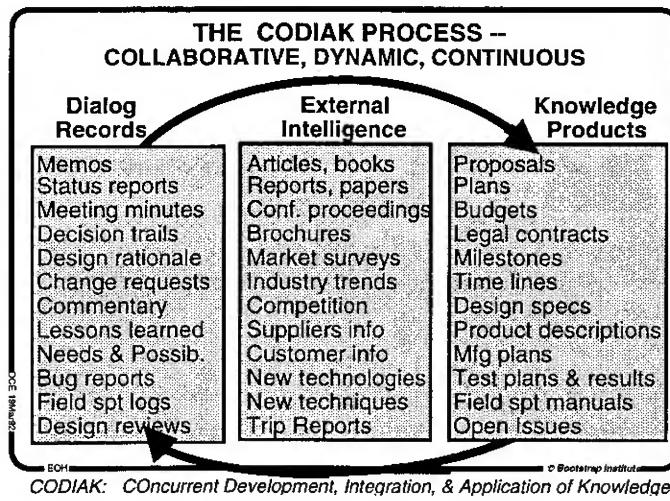


Figure 7

With minor adjustments in the boxed lists in Figure 7, this basic generic CODIAK model seems to apply equally well to academic scholarship, heavy industry, government, medical research, social institutions, consumer product businesses, consulting firms, trade associations, small non-profits, and so on.

We need to note here that basic CODIAK processes have practically forever been a part of society's activity. Whether the knowledge components are carried in peoples' heads, marked on clay tablets, or held in computers, the basic CODIAK process has always been important.

What is new is a focus toward harnessing technology to achieve truly high-performance CODIAK capability. As we concurrently evolve our human-system elements and the emergent groupware technology, we will see the content and dynamics represented in Figure 7 undergo very significant changes.

More and more intelligence and dialog records will end up usefully recorded and integrated; participants will steadily develop skills and adopt practices that increase the utility they derive from the increased content, while at the same time making their contributions more complete and valuable.

Generally, I expect people to be surprised by how much value will be derived from the use of these future tools, by the ways the value is derived, and by how "natural and easy to use" the practices and tools will seem after they have become well established (even though they may initially be viewed as unnatural and hard to learn).

Inevitably, the groupware tools which support the CODIAK processes within and across our organizations will need to be fully integrated and fully interoperable. Consider the larger

organization depicted in Figure 8 in which our representative complex project may be embedded (for example, in the Engineering Department of a manufacturing organization).

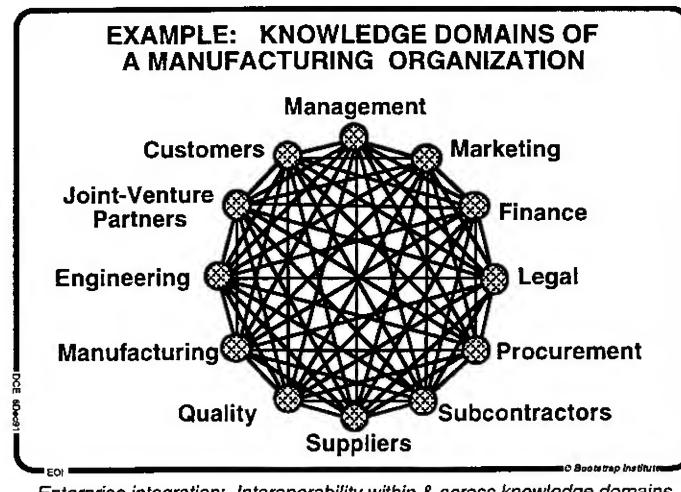


Figure 8

*Enterprise integration: Interoperability within & across knowledge domains*

Each of the enterprise's functional units studded around the circle represents an activity domain that houses at least one CODIAK process. Then, because of their mutual involvement with the operations of the whole enterprise, the CODIAK processes within each of these enterprise sub-domains would with strong likelihood benefit from being interoperable with those of the other sub-domains.

As operations between enterprises steadily become more closely knit, the interaction processes with customers, subcontractors and suppliers also want to become increasingly effective — and therefore the issue of knowledge-domain interoperability becomes ever more global.

As developed in the sections that follow, our framework assumes that all of the knowledge media and operations indicated in Figure 7 will one day be embedded within an Open Hyperdocument System (OHS). Every participant will work through the windows of his or her workstation into his or her group's "knowledge workshop."

With this in mind, consider the way in which the project group's CODIAK domain, with all of its internal concurrent activity, will be operating within the larger enterprise group depicted in Figure 8.

And consider that the whole enterprise, acting as a coherent organizational unit, must also have a workable CODIAK capability and possess its own evolving, applicable CODIAK knowledge base.

Here an important appreciation may be gained for the "concurrency" part of the CODIAK definition. CODIAK was introduced above with the sense that all of the development, integration and application activities within a given organizational unit were going on concurrently. *This establishes a very important requirement for the groupware support.*

In Figure 9 we get the sense of the multi-level "nesting" of concurrent CODIAK processes within the larger enterprise. Each of the multiply-nested organizational units needs its own coherent CODIAK process and knowledge base; and each unit is running its CODIAK processes concurrently, not only with all of its sibling and cousin units -- but also with larger units in which it is embedded, and with smaller units that are part of its own makeup.

Furthermore, there are many valuable organizational units that cut across the organizational structure — such as a corporate-wide task force — and each of these units also needs a coherent CODIAK process and knowledge base. And beyond that, significant working relationships will be going on with external organizational units, such as trade associations, professional societies, consultants, contractors, suppliers, special alliance partners, customers, regulatory agencies, and standards groups. Each such "external" unit needs to have a coherent CODIAK knowledge domain; all such domains will have some knowledge elements and evolutionary dynamics that are mutual with those of many other units in the enterprise's total CODIAK environment.

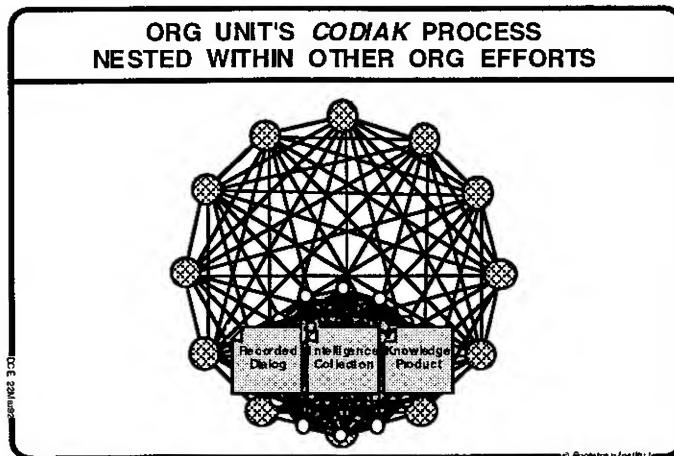


Figure 9

So, consider the much extended sense of concurrency and inter-dependency arising from the above picture: the CODIAK processes of all of the inter-dependent organizational units within the larger enterprise are going on concurrently; and further, among these concurrently active processes there is a great deal of mutual involvement with parts of the whole knowledge base.

It is easy to realize that significant parts of what the smaller group works with, as being in its "external environment" intelligence collection, will actually be shared-access knowledge from other domains within the enterprise — from other's dialog, from their external intelligence, or from their finished or evolving knowledge products.

Then the entire enterprise has a collective CODIAK domain, with knowledge elements that to some extent will be actually in a "whole-enterprise" domain, but where much of what lies in the collective enterprise domain is an active part of the CODIAK domains of subordinate organizational units within the enterprise.

And further, consider that as the availability of highly effective online CODIAK support becomes widespread, suppliers, contractors and customers will engage in a non-trivial degree of CODIAK-domain sharing with the enterprise. One needs only a brief glance at the supplier network of Figure 10 to realize the magnitude of critical, interoperable CODIAK processes and shared CODIAK knowledge domains that will prevail when (or if) suitable groupware becomes widely available.

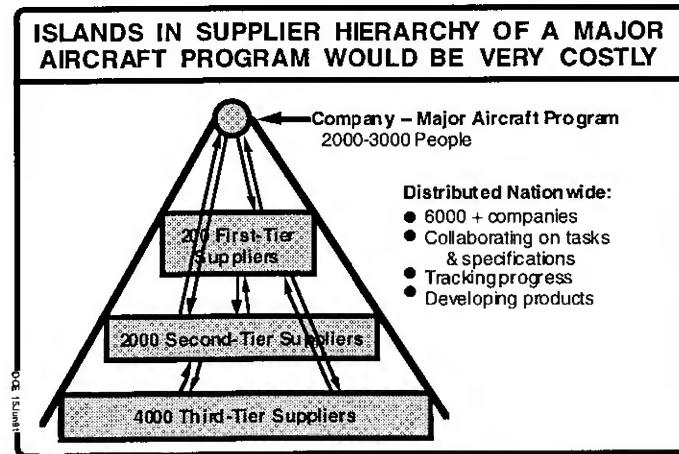


Figure 10

This is representative of the scale of global challenge that I think faces the groupware marketplace.

The foregoing dictates some very significant requirements for any groupware system that attempts to support the CODIAK processes of our future, high-performance organizations. Immediately apparent is the need for very flexible, wide-area sharing of pieces of the knowledge base. What has only recently begun to be generally apparent is the associated need for a new way of thinking about the nature of the knowledge packages we have called "documents." This above requirement for flexibly arranged sharing of essentially arbitrary knowledge chunks provides a very strong argument for documents becoming built from modular-concept nodes with arbitrary inter-node linking — *hypertext*.

So, how (and when) will the marketplace learn enough and be cooperative enough to develop truly effective OHS standards? The prospects for achieving truly high levels of performance in larger organizations and institutions pretty much await that day.

This question is a significant part of what an effective bootstrapping strategy needs to address.

## 6 OPEN HYPERDOCUMENT SYSTEM (OHS): FOR GENERIC CODIAK SUPPORT

My early assumption, amply borne out by subsequent experience, is that the basic supporting technology for future high-performance knowledge work will be an integrated system based upon multi-media hyperdocuments.

Furthermore, there will be critical issues of interoperability within and between our organizations and their knowledge domains. The ever-greater value derived from online, interactive work within a hyperdocument environment will require a significantly higher degree of standardization in document architecture and usage conventions than heretofore contemplated.

It is inevitable that this service be provided by an "open system" of hyperdocuments and associated network and server architectures. The basic arguments for this Open Hyperdocument System (OHS) are presented in Ref-5; and the hyperdocument system features described below are assumed by me to be strong candidates for requirements for the eventual OHS whose evolution will be so critical to the productivity of industries and nations.

Following is a brief general description of the system design that has evolved from the conceptual orientation described in this paper, through the experience of many years and trial events. Please note that the term "system" is very important here.

**Shared Files/Documents** — the most fundamental requirement. Generalized file sharing is to be available across the entire global domain in which any online collaborative working relationship is established (e.g., world-wide).

**Mixed-Object Documents** — to provide for an arbitrary mix of text, diagrams, equations, tables, raster-scan images (single frames or live video), spread sheets, recorded sound, etc. — all bundled within a common "envelope" to be stored, transmitted, read (played) and printed as a coherent entity called a "document."

**Explicitly Structured Documents** — where the objects comprising a document are arranged in an explicit hierarchical structure, and compound-object substructures may be explicitly addressed for access or to manipulate the structural relationships.

**Global, Human-Understandable, Object Addresses** — in principle, every object that someone might validly want/need to cite should have an unambiguous address, capable of being portrayed in a manner as to be human readable and interpretable. (E.g., not acceptable to be unable to link to an object within a "frame" or "card.")

**View Control of Objects' Form, Sequence and Content** — where a structured, mixed-object document may be displayed in a window according to a flexible choice of viewing options — especially by selective level clipping (outline for viewing), but also by filtering on content, by truncation or some algorithmic view that provides a more useful portrayal of structure and/or object content (including new sequences or groupings of objects that actually reside in other documents). Editing on structure or object content directly from such special views would be allowed whenever appropriate.

**The Basic "Hyper" Characteristics** — where embedded objects called *links* can point to any arbitrary object within the document, or within another document in a specified domain of documents — and the link can be actuated by a user or an automatic process to "go see what is at the other end," or "bring the other-end object to this location," or "execute the process identified at the other end." (These executable processes may control peripheral devices such as CD ROM, video-disk players, etc.)

**Hyperdocument "Back-Link" Capability** — when reading a hyperdocument online, a worker can utilize information about links from other objects within this or other hyperdocuments that point to this hyperdocument — or to designated objects or passages of interest in this hyperdocument.

**Link Addresses That Are Readable and Interpretable by Humans** — one of the "viewing options" for displaying/printing a link object should provide a human-readable description of the "address path" leading to the cited object; AND, the human must be able to read the path description, interpret it, and follow it (find the destination "by hand" so to speak).

**Personal Signature Encryption** — where a user can affix his personal signature to a document, or a specified segment within the document, using a private signature key. Users can verify that the signature is authentic and that no bit of the signed document or document segment has been altered since it was signed. Signed document segments can be copied or moved in full without interfering with later signature verification.

**Hard-Copy Print Options to Show Addresses of Objects and Address Specification of Links** — so that, besides online workers being able to follow a link-citation path (manually, or via an

automatic link jump), people working with associated hard copy can read and interpret the link-citation, and follow the indicated path to the cited object in the designated hard-copy document.

Also, suppose that a hard-copy worker wants to have a link to a given object established in the online file. By visual inspection of the hard copy, he should be able to determine a valid address path to that object and for instance hand-write an appropriate link specification for later online entry, or dictate it over a phone to a colleague.

**Hyperdocument Mail** — where an integrated, general-purpose mail service enables a hyperdocument of any size to be mailed. Any embedded links are also faithfully transmitted — and any recipient can then follow those links to their designated targets that may be in other mail items, in common-access files, or in "library" items.

**The Hyperdocument "Journal System"** — an integrated library-like system where a hyperdocument message or document can be submitted using a submittal form (technically an email message form), and an automated "clerk" assigns a catalog number, stores the item, notifies recipients with a link for easy retrieval, notifies of supercessions, catalogs it for future searching, and manages document collections. Access is guaranteed when referenced by its catalog number, or "jumped to" with an appropriate link. Links within newly submitted hyperdocuments can cite any passages within any of the prior documents, and the back-link service lets the online reader of a document detect and "go examine" any passage of a subsequent document that has a link citing that passage.

**Access Control** — Hyperdocuments in personal, group, and library files can have access restrictions down to the object level.

**External Document Control (XDoc)** — (Not exactly a "hyperdocument" issue, but an important system issue here.) Documents not integrated into the above online and interactive environment (e.g. hard-copy documents and other records otherwise external to the OHS) can very effectively be managed by employing the same "catalog system" as for hyperdocument libraries — with back-link service to indicate citations to these "offline" records from hyperdocument (and other) data bases. OHS users can find out what is being said about these "XDoc" records in the hyperdocument world.

The overview portrayal in Figure 11 shows the working relationships between the major system elements described above. Note the shared catalog service that supports use of the Journal and External Document services.

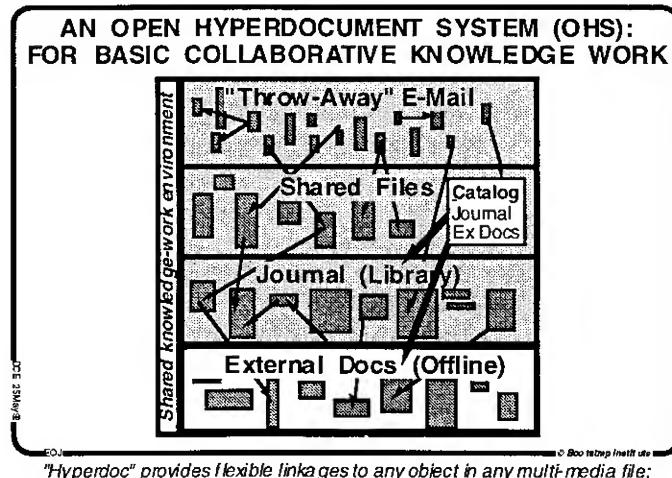


Figure 11

Details of features and designs for well-developed prototypes of some of the above may be found in Ref-6, Ref-7 and Ref-8.

## 7 FOUR GENERAL GROUPWARE ARCHITECTURAL REQUIREMENTS

Besides the aforementioned Hyperdocument Mail and Hyperdocument Library features that depend upon special larger-scale architectural features, there are at least four other important tool-system capabilities that are very important to wide-area groupware services such as being considered here:

***Global and Individual Vocabulary Control*** — somewhat new in the history of computer services are issues regarding the evolution and use of a common "workshop vocabulary" among all the users of the forthcoming "global knowledge workshop." Common data dictionaries have been at issue, of course, but for a much more limited range of users, and for a more limited and stable vocabulary than we will face in the exploding groupware world.

Our own architectural approach (see Ref-6, Ref-9 and Ref-10) has been to introduce into every user-interface environment a common Command-Language Interpreter (CLI) module that derives the user's available operations (verbs) as applied to the available classes of objects (nouns) from a grammar file (individualized if desired with respect to the size and nature of the verbs and nouns utilized from the common vocabulary). The CLI interprets user actions, based upon the contents of the currently attached grammar file, and executes appropriate actions via remote procedure calls to a common application program interface of the "open system environment."

Each of us knowledge workers will become involved in an ever richer online environment, collaborating more and more closely within an ever more global "knowledge workshop," with multi-organizational users of widely divergent skills and application orientations who are using hardware and software from a wide mix of vendors.

Without some global architectural capability such as suggested above, I can't see a practical way to support and control the evolving global "workshop vocabulary" in a manner necessary for effectively integrating wide-area groupware services.

***Multiplicity of Look-and-Feel Interface Choices*** — Based upon the same Command-Language Interpreter (CLI) architecture as above, a "look-and-feel interface" software module would be located between the CLI and the window system. Providing optional modules for selected look-and-feel interface characteristics would serve an important practical as well as evolutionary need.

There would be a basic constraint necessary here. When working interactively, no matter what particular look-and-feel style is being used, a user has a particular mental model in mind for the significance of every menu item, icon, typed command, or "hot, command-key combination" employed.

The necessary constraint needed here is that the resulting action, via the interface module that is being employed for this user, must be produced through the underlying execution of processes provided by the Command Language Interpreter module as derived from use of common-vocabulary terms. And the users should learn about their tools and materials, and do their discussing with others about their work, using the underlying common-vocabulary terms no matter what form of user interface they employ.

Besides relaxing the troublesome need to make people conform to a standard look and feel, this approach has a very positive potential outcome. So far, the evolution of popular graphical user interfaces has been heavily affected by the "easy to use" dictum. This has served well to facilitate wide acceptance, but it is quite unlikely that the road to truly high performance can effectively be traveled by people who are stuck with vehicular controls designed to be easy to use by a past generation.

As important classes of users develop larger and larger workshop vocabularies, and exercise greater process skill in employing them, they will undoubtedly begin to benefit from significant changes in look and feel. The above approach will provide open opportunity for that important aspect of our evolution toward truly high performance.

**Shared-Window Teleconferencing** — where remote distributed workers can each execute a related support service that provides the "viewing" workers with a complete dynamic image of the "showing" worker's window(s). Used in conjunction with a phone call (or conference call), the parties can work as if they are sitting side-by-side, to review, draft, or modify a document, provide coaching or consulting, support meetings, and so on. Control of the application program (residing in the "showing" worker's environment) can be passed around freely among the participants. Generic provision of this service is discussed in Ref-6.

**Inter-Linkage Between Hyperdocuments and Other Data Systems** — for instance, a CAD system's data base can have links from annotations/comments associated with a design object that point to relevant specifications, requirements, arguments, etc. of relevance in a hyperdocument data base — and the back-link service would show hyperdocument readers which passages were cited from the CAD data base (or specified parts thereof).

Similarly, links in the hyperdocuments may point to objects within the CAD bases. And, during later study of some object within the CAD model, the back-link service could inform the CAD worker as to which hyperdocument passages cited that object.

## 8 THE CODIAK PROCESS SUPPORTED BY AN OHS

With the above tool capabilities, together with well-developed methods and other human-system elements as discussed in section 1.2, the organization's capability infrastructure could support the following types of online CODIAK scenarios.

Note that the following online interactions are designed to work even if the users are in different organizational units, in different organizations, using different application packages on different workstations (assuming access to the data is not barred by the stringent privacy features, naturally). The real test of an OHS is when you can click on a link you received via email from someone in a different organization, jumping directly to the passages cited, and then comfortably maneuver through the "foreign" knowledge domain, possibly jumping up a level with an outline view to see the context of the given passage, following other links you find there, and so on, *without having to fumble through unfamiliar processes*.

**Intelligence Collection:** Now an alert project group, whether classified as an A, B, or C Activity, can keep a much enhanced watchful eye on its external environment, actively surveying, ingesting, and interacting with it mostly online. Much of the external intelligence is now available in hyperdocument, multimedia form, having been captured in an OHS Journal facility. When I send you an email to let you know about an upcoming conference, I can cite the sessions I think you'd be interested in, and you can click on the enclosed citation links to quickly access the cited passages (taking advantage of hypertext links and object addressability). When I do a search through the Journal catalogs to research

a question for the proposal I am writing, I can see who has cited the material and what they had to say about it. If the material is offline (i.e. in XDoc), I can quickly discover where it is stored and how to obtain a copy, probably requesting it via email. If the material is online, I can access it instantly, usually starting with a top-level outline view of the document's titles (taking advantage of the OHS document structure and custom viewing features), possibly setting a simple filter to narrow the field, then quickly zooming in on the specific information I require. I can quickly build an annotated index to the intelligence documents, or objects within those documents, that I want to keep track of. I can share with you a macro I wrote to trap certain incoming intelligence items and reformat them in a certain way, and you could fire this up in your own environment to work off your pet keywords (taking advantage of the common-vocabulary architectural feature). All the intelligence collected is easily integrated with other project knowledge.

**Dialog Records:** Responding effectively to needs and opportunities involves a high degree of coordination and *dialog* within and across project groups. In an OHS environment, most of the dialog will be conducted online via the Journal. Email would be used mostly for "throw-away" communiqués, such as meeting reminders. All memos, status reports, meeting minutes, design change requests, field support logs, bug reports, and so on, would be submitted to the Journal for distribution. Asynchronous online conferencing would be supported by the Journal, with each entry tagged and catalogued for easy future reference. Document exchange would be a matter of submitting the document to the Journal with a comment such as "Here's the latest version — please note especially the changes in Section G, differences are listed in File Y" including links to that section and that file for easy access. The reviewers would click on the links, and proceed to review the document. To make a comment, the reviewer would click on the object in question, and enter the comment, such as "Replace with 'Xyz,'" or "Watch out for inconsistencies with Para G4!" with a link to the passage in G4. The author then gets back the indexed comments, and has many options for quickly reviewing and integrating them into the document. Such dialog support will obviate the need for many same-time meetings.

Same-time meetings, when needed, would be greatly enhanced by an OHS. The dialog motivating the meeting would already be in the Journal. Agenda items would be solicited, and the agenda distributed via the Journal. At the meeting, the agenda and real-time group notes can be projected on a large screen, as well as displayed on each participant's monitor (using the "shared screen" feature), and any participant can point to the displayed material (e.g. using a mouse). Controls can be passed to any participant to scribble, type, or draw on this virtual chalkboard. Any presentation materials and supporting documents can be instantly retrieved from the knowledge base for presentation. All resulting meeting documents, along with references to supporting documents cited, would subsequently be submitted to the Journal for immediate access by all authorized users.

In addition, tools will soon become generally available for flexibly contributing, integrating, and interlinking digitized speech into the OHS knowledge base. Early tools would be available for speaker recognition, for special-word recognition, and even for basic transcription to text — and for installing and following links between modules as small as a word embedded in a long speech string. This will greatly enhance the development, integration, and application of dialog records. More elegant tools will follow, and as human conventions and methods evolve to make effective use of the technology, the quantity and completeness of recorded dialog will become much more significant.

**Knowledge Product:** Throughout the life cycle of the project, the online OHS knowledge product will provide a truly comprehensive picture of the project at hand. Intermediate project states, including supporting intelligence and dialog trails, can be bundled as document collections in the Journal for document version management. All knowledge

products will be developed, integrated, and applied within an OHS, with concurrent contributions from many diverse and widely distributed users. These users can also work as if sitting side by side, reviewing a design, marking up a document, finalizing the changes, etc. (using the shared screen feature). Finding what you need among the thousands of project documents will be a simple matter of clicking on a link (provided by the Journal catalogs, or by your project's indices), and zooming in and out of the detail, or by having someone else "take you there" (using the shared screen feature). Accountability is absolute—Journal submittals are guaranteed to be authentic, and each object can be tagged by the system with the date and time of the last write, plus the user who made the change. Documents can be signed with verifiable signatures.

Everyone is but one quick "link hop" away from any piece of knowledge representation anywhere in the whole knowledge collection. Smart retrieval tools can rapidly comb part or all of the collection to provide lists of "hit links" with rated relevance probabilities.

Conventions for structuring, categorizing, labeling and linking within their common knowledge domain will be well established and supportive of a high degree of mobility and navigational flexibility to experienced participants — much as residents get to know their way effectively around their city if they get much practice at it.

As a group adapts its ways of working to take better advantage of a tool system such as projected here, the classes of knowledge objects will grow, as will the functions available to operate upon them—and that growth will be paralleled by the concurrent evolution of an ever richer repertoire of the humans' "workshop knowledge, vocabulary, methodology and skills."

There is tremendous potential here, and many methods, procedures, conventions, organizational roles to be developed in close association with the tools. And, if the OHS is to be *open*, there is much deep exploration to be done into different application domains, such as Computer-Supported Cooperative Work (CSCW), organizational learning, Total Quality Management (TQM), Enterprise Integration (EI), program management, Computer-Aided Software Engineering (CASE), Computer-Aided Engineering (CAE), Concurrent Engineering (CE), organizational memory, online document delivery and CALS, and so on. This will require many advanced pilots, as will be discussed further on.

## **9 RECAP: THE FRAMEWORK TO THIS POINT**

To this point in the paper, we have outlined steps in the development of a strategy to provide a high-leverage approach toward creating truly high-performance organizations.

We considered the concept of the organization's *capability infrastructure* upon which any of the organization's effectiveness must depend.

Further, what enables humans to exercise this infrastructure of capabilities is an *Augmentation System*, which is what provides the humans with all capabilities beyond their genetically endowed basic mental, motor and perceptual capabilities. It was useful to divide the Augmentation System into two sub-systems, the Human System and the Tool System. "Organic style co-evolution" among the elements of our Augmentation System has been the process by which it evolved to its current state.

New technologies are introducing an unprecedented scale of improvement in the Tool System part of the Augmentation System. This promises that subsequent co-evolution of our Augmentation Systems will likely produce radical qualitative changes in the form and functional effectiveness of our capability infrastructures, and hence of our organizations.

Very large and challenging problems are envisioned in pursuing potential benefits of such changes, towards truly high-performance organizations. A strategy is sought to provide an effective approach.

It would be profitable to consider early focus on improving the organizational improvement process so that further improvements can be done more effectively.

To help with this analysis, the ABC categorization of improvement-process was established. And the thesis was developed that the CODIAK set of knowledge capabilities — the concurrent development, integration, and application of knowledge — is important to all three types of activities. Therefore, if CODIAK improvement was concentrated upon early, the result could improve the first and second derivatives of the return on future improvement investments.

An Open Hyperdocument System (OHS) would be a key "Tool System" development towards improving general and widespread CODIAK capabilities within and between organizations. And creating a truly effective OHS would in itself be an extremely challenging and global problem for our groupware marketplace.

So, high-performance organizations: great opportunities, interesting concepts, tough challenges. What next regarding strategy?

## 10 C COMMUNITY: HIGH-PAYOUT BOOTSTRAPPING OPPORTUNITY

Returning to the basic ABC Model in Figure 4, we can make a few useful observations toward a next step in strategy development. This model will be useful even if the Bootstrapping approach is not followed; it is valuable to become explicit about differentiating responsibilities, functions and budgets between the two levels of improvement activity (B and C).

If explicit C roles are designated and assumed, basic issues will soon arise for which the C-Activity leaders find it valuable to compare experiences and basic approaches with their counterparts in other organizations. For instance, what budgeting guidelines and targets make sense for these improvement activities? How much can it help the B Activity to document the way things are done now? What role should pilot applications play? How large an improvement increment, for how big a group, does it make sense to try for a pilot? How much "instrumentation" of a pilot group — before, during, and after transition — to measure the value of the effort? These are all relevant to making the B Activity more effective.

So let us consider formalizing and extending the above type of cooperation among improvement activities, especially the C Activities. In the mid-60s I began to think about the nature and value of communities of common interest formed among different improvement activities. This led me very early to build explicit planning into the bootstrap strategy for forming improvement communities.

In Ref-11 (1972), I presented the concept of a "community knowledge workshop" -- outlining the tools we had developed for supporting it (including many of the hyperdocument system capabilities outline above), and described the three basic CODIAK sub-domains: recorded dialog, intelligence collection, and what I then called the "handbook" (or knowledge products).

After the ABC Model emerged in the framework, this evolved into a special emphasis on an important launching phase, for forming one or more special bootstrapping C Communities as shown in Figure 12.

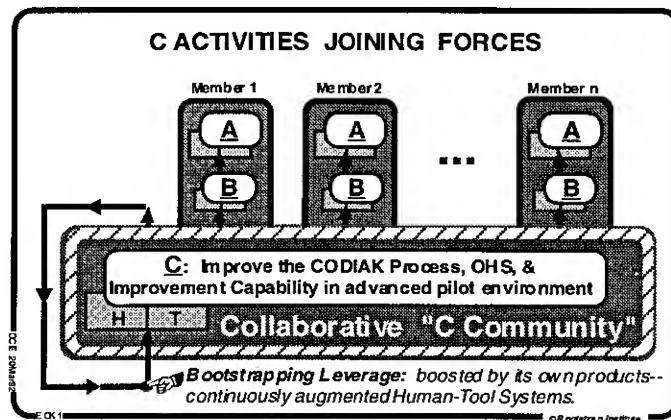


Figure 12

The value of such a cooperative activity can be very high — we'll unveil some of that later. First, there are some other questions that naturally arise which need to be addressed. An early and common pair of comments are: "I can't imagine sharing things with my competitors, there is so much about what we do that is proprietary;" and, "If they aren't in the same business, I don't see what useful things there would be that we could share."

About proprietary matters: The A Activity of each organization may be very competitive, with considerable proprietary content. The B Activity of each would tend to be less so — having quite a bit that is basic and generic. The C Activity of each would be much less involved in proprietary issues, and much more in basic, generic matters. So even competitors could consider cooperating, "out of their back doors" — "while competing like hell out of our front doors," as a trend that seems to be appearing among companies heavily into Total Quality Management and pursuit of the Malcolm Baldridge Award.

About being in very different business: Again, their B Activities will be much less different, and their C Activities surprisingly alike in important basic and generic issues.

Now, consider how a C Community could operate if it had the basic hyperdocument tools described above. For several decades, my colleagues and I have had such a system available, so all of our scenarios began there, using that system and calling it our "OHS, Model 1" — or "OHS-1."

And how would an ideal bootstrapping C Community operate? Its earliest focus would be on augmenting its own CODIAK capability. Using OHS-1 to do its work; making an important part of its work at first be to establish requirements, specifications and a procurement approach for getting a set of rapidly evolving prototype hyperdocument systems (e.g. OHS-2, -3, etc.), to provide ever better support for serious pilot applications among the C Community participants.

The Community's basic knowledge products could be viewed as dynamic electronic handbooks on "how to be better at your improvement tasks," with two customer groups: its B-Activity customers; and the C Community itself. Pooling resources from the member organizations enables a more advanced and rapidly evolving prototype CODIAK environment, which serves two very important purposes:

1. It provides for the Community getting better and better at its basic "C Activity;"
2. It provides advanced experience for its rotating staff of participants from the member organizations. They thus develop real understanding about the real issues

involved in boosting CODIAK capability — this understanding being absorbed by “living out there in a real, hard-working CODIAK frontier.”

Note that it would be much more expensive for each member organization to provide equivalent experience by operating its own advanced pilot. Also the amount of substantive knowledge product developed this way would be very much more expensive if developed privately.

An important feature: once the Community stabilizes with effective groupware tools, methods and operating skills, the participants from the respective member organizations can do most of their work from their home-organization sites. This provides for maintaining the organizational bonding which is very important in effective C and B activities.

This home-site residency also facilitates the all-important “technology transfer” from the C Community into its customer B Activities. And, while considering the issue of “technology transfer,” note that a strong feature of an augmented CODIAK process is the two-way transfer of knowledge. Developing dialog with the B clients via joint use of the hyperdocument system not only facilitates directly this two-way knowledge transfer, but provides critically important experience for the B people in the close witnessing of how advanced CODIAK processes work.

To characterize the value of facilitating this two-way transfer, consider Figure 13, which highlights the basic importance of improved CODIAK processes in the organization's improvement activity. The “1, 2, 3” points all are basic to the CODIAK process. As augmented CODIAK capabilities make their way up from C to B and into A, the over-all improvement process can't help but improve. And also, note that when the A Activity for this organization, as well as those for its customers, become based on interoperable CODIAK processes, the dynamics of the whole business will begin to sparkle.

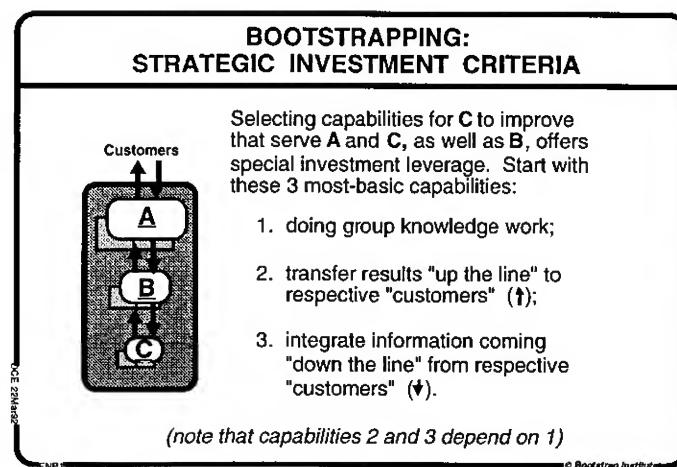


Figure 13

Now consider Figure 14, and note that the indicated types of knowledge flow are basic to the CODIAK processes, and that augmenting those processes for the C Community directly boosts one of its core capabilities. Conversely, Figure 15 emphasizes the previous basic point of the naturalness for enhanced CODIAK to improve this outflow, and highlights again the basic bootstrapping value that is obtained from early focus on these CODIAK processes.

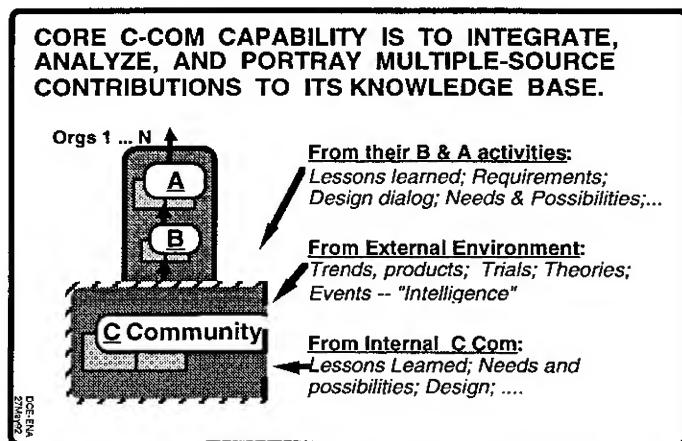


Figure 14

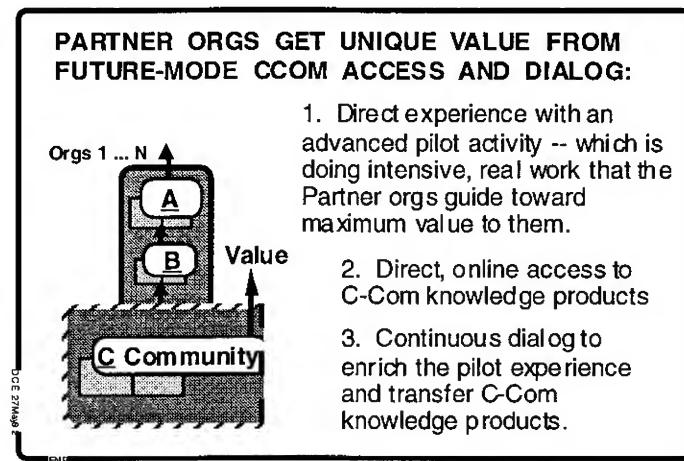


Figure 15

In the organizational improvement domain, there are several immediately apparent large and explicit issues for which a lone organization would need to consider a multi-party alliance. An immediate such issue, from the bootstrapping point of view, is to procure appropriate groupware systems that can support advanced pilot applications. Other large-sized issues have to do with "exploration and outpost settlements."

Relative to the options opening to our organizations for transforming into new states, there is a very large, unexplored, multi-dimensioned frontier out there. Both its dimensionality and its outer boundaries are expanding faster and faster. To really learn about that frontier, in order to decide where we would want to "settle our organizations," we must somehow do a great deal of basic exploration work. We also need to establish a significant number of outpost settlements in promising places so as to find out ahead of time what it would be like to really live and work there. (Translate "outposts" into "advanced pilot groups.")

Yet we are launching very few exploratory expeditions and developing very few significant outposts.

From the viewpoint that I have acquired, there is a great need for such explorations and trial settlements. Much of my motivation for advocating such as C Communities, bootstrapping, CODIAK and OHS pursuits, etc., is to find a strategy for exploring and settling that territory. It is almost like a military strategy: "first we get a firm settlement here in

CODIAK territory; then with that as a base, we encircle the OHS and C territories; when we get those under reasonable control, we will be in a most advantageous posture to pour through the rest of the B and C Improvement Territories to get the whole area under control and ..."

As the C Community and its working relationship with its "B customer" matures, there can be integrated into the substance of their joint efforts an ever larger sphere of involvement with the whole set of issues of organizational improvement.

Potential customers for augmented CODIAK capabilities can be seen everywhere in today's global society: e.g., all of the "Grand Challenges" earmarked in the U.S. for special support. Essentially every professional society will eventually operate this way; as will legislative bodies and government agencies, and university research programs.

In short, our solutions to every other challenging problem that is critical to our society will become significantly facilitated by high-performance CODIAK capabilities. Provides a stimulating challenge for the groupware community, doesn't it?

In closing, I would like to re-emphasize the comments in Section 1.4 about paradigms. I am convinced that cultivating the appropriate paradigm about how to view and approach the future will in the pursuit of high-performance organizations be the single most critical success factor of all.

[Note: The Bootstrap Institute has developed basic plans for several scales of C-Community launching — a medium-sized consortium approach on the one hand, and a more conservative, organic evolution approach on the other hand. Interested inquiries are invited.]

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## Notes

Also republished in *Computer Supported Cooperative Work: A Book of Readings*, Irene Greif [Ed.], Morgan Kaufmann Publishers, San Mateo, CA, 1988, pp. 107-126. Also published in *Groupware: Software for Computer-Supported Cooperative Work*, D. Marca & G. Bock [Ed.], IEEE, 1992.

## AUTHORSHIP PROVISIONS IN AUGMENT

**Douglas C. Engelbart**  
Tymshare, Inc., Cupertino, CA  
Journal (OAD,2250)  
December 9, 1983

1

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## ABSTRACT

2

AUGMENT is a text processing system marketed by Tymshare for a multi-user, network environment. In AUGMENT's frontend is a User Interface System that facilitates flexible evolution of command languages and provides optional command recognition features. Exceptionally fast and flexible control of interactive operations is enabled by concurrent action of mouse and optional one-handed chord keyset. Files are hierarchically structured, and textual address expressions can flexibly specify any text entity in any file. The screen may be divided into arbitrary, rectangular windows, allowing cross-file editing between windows. Many options exist for controlling the "view" of a file's text in a window, e.g.: level clipping, paragraph truncation, and content filtering. Structural study and modification of on-line documents are especially facilitated. A Journal system and "Shared Screen Teleconferencing" support collaboration among authors and their colleagues. Graphic illustrations may be embedded in the same file with text.

2a

## INTRODUCTION

3

AUGMENT was designed for augmenting human intellectual capabilities. It was targeted particularly toward the core work of professionals engaged in "tough knowledge work" -- e.g., planning, analyzing, and designing in complex problem domains. And special attention was paid to augmenting group collaboration among workers pursuing common goals.

3a

Authorship has received a great deal of attention in AUGMENT's evolution, as one of the central human activities to be augmented. An important set of provisions within AUGMENT -- in its architecture, design principles, and specific features -- is directly aimed toward bringing high performance to the authorship activities of knowledge workers. For the purposes of this paper, we thus speak interchangeably of "knowledge worker" and "author."

3b

We recognize explicitly that highly skilled workers in any field, and knowledge work is no exception, are those with good command of their tools. Our basic design goal was to provide a set of tools that would not themselves limit the

capabilities of the people using them. A system designed to encourage more skilled workers will always enable higher human performance than one designed to support less skilled workers.

3c

In this regard, our design goal was to provide as much capability as possible for each level of system usage skill, and a continuous evolution path between skill levels. We believe firmly that knowledge workers are motivated to grow in knowledge and skill and that provisions in system design should support this. As the rest of the paper reveals, this approach translates into a rich set of AUGMENT provisions, aimed at providing speed and flexibility for skilled workers in organizing and pursuing their core knowledge work -- in which "authorship" is a primary activity.

3d

An explicit sub-goal in AUGMENT's development was to "augment" the development, production and control of complex technical documentation -- through the whole cycle of gathering information, planning, creating, collaborating, reviewing, editing, controlling versions, designing layout, and producing the final documents.

3e

This paper concentrates upon the development phase of this cycle. AUGMENT has well-developed tools to support the later, production phase, but their discussion is not included here.

3f

Studying another's work provides a well-recognized challenge, but one of the toughest jobs is to study one's own work during its development: to see what it really says about Issue X; to see if it does provide for Concept Y; to see if it is reasonably organized and structured -- and to do these over a body of material before it is "polished", i.e., before it is well structured, coherently worded, non-redundant and consistently termed.

3g

## SOME BACKGROUND

4

### HISTORY

4a

AUGMENT is an integrated system of knowledge-worker tools that is marketed by Tymshare's Office Automation Division. The system was developed at SRI International over an extended period under the sponsorship of NASA, DARPA, and RADC. Commercial rights were transferred to Tymshare in 1978 (where the system has since been renamed from NLS to AUGMENT) and its evolution continued. A short history of AUGMENT's development may be found in <Ref-1>, along with a summary of system characteristics and features. The general R&D philosophy and the design principles behind AUGMENT'S development are laid out in <Ref-2>.

4a1

The system evolved on time-shared, mainframe computers, and in a packet-switched network environment. In 1970 our computer was the second to be

attached to the ARPANET, and since 1978 we have also operated extensively in the TYMNET environment. We have benefited directly from both the time-sharing and the network environments in matters that are important to the authorship process -- especially in dealing with large documents and multi-party documentation activities. In 1976-77 we conducted some applied studies for the Air Force, as reported in <Ref-3> and <Ref-4>, which concentrated upon this latter application.

4a2

## RELEVANT ARCHITECTURAL FEATURES

4b

Perhaps AUGMENT's most unique architectural feature is its User Interface System (UIS), a special software module, which handles the human/computer interfaces to all interactive programs. It takes care of all command-language dialog and connection protocols, and provides a framework for building a coherent and integrated user environment while supporting flexible evolution on both sides: on the user's side, with evolution of command function and terminology; and on the technology side, with evolving hardware and software. (Design details are outlined in <Ref-5>; rationale and utilization in <Ref-6>.)

4b1

The UIS provides a reach-through service to non-AUGMENT systems, and can optionally translate back and forth to a foreign program's command language. It also supports the shared-screen, remote collaboration capability discussed below.

4b2

AUGMENT's architecture provides for open-ended expansion and flexible evolution of system functionality and worker command languages.

4b3

It is assumed that for any class of knowledge workers, specialized application systems developed by other parties, perhaps running on other computers, will provide services worth integrating. The "author class" of worker should be no exception. Continuing evolution toward the "author workshop of the future" will certainly depend upon some such features in workshop architecture.

4b4

It provides adaptation for different terminal characteristics, enabling application programmers to work as though with a virtual terminal.

4b5

## FILE CHARACTERISTICS

4c

AUGMENT employs explicitly structured files, with hierarchically organized nodes; each node can contain either or all of: up to 2,000 characters of text, a graphic structure, or other forms of useful data (e.g., digitized speech). The worker has a definite model in mind for the structuring of any file that he works with; in composing and modifying it he can organize and modify structure using the same verbs as for working with text strings (e.g. Insert, Replace, Move, Copy, Delete), with appropriate structural-entity nouns (e.g., Statement, Branch, Group, Plex). For any existing hierarchical structure, he

has many flexible alternatives for addressing its entities, modifying its organization, jumping around within it, and viewing it in a most beneficial manner.

4c1

(Note: AUGMENT workers generally use the term "statement" to refer to a file node, which is natural enough since the terminology became established before we added the graphic capability. Now an AUGMENT "statement" can contain either or both a text statement and a graphic diagram.)

4c2

## CONTROLLING THE TOOLS

5

Many of AUGMENT's unique author-support provisions address basic operations common to almost every task, things done over and over again. These operations, executed with speed and flexibility, provide for composing and modifying one's working material, and for studying what is there over a wide range of substantive levels -- from a single text passage to a collection of end-product draft documents and their associated set of working notes, reference material, and recorded-message dialog (assuming all to be on line).

5a

In the early stages of our program at SRI, we did a great deal of detailed work on what we called the "control interface" -- how users control the functional application of their tools. These details can be very important to "low-level" interactions which are done hundreds of times during a working day. Some of these details are quite relevant to bringing high performance to the authorship process.

5b

AUGMENT commands are expressed with verbs, nouns, and appropriate qualifier words; every command word is designated by entering one or more characters. The UIS recognizes the command word from these characters according to the command-recognition options designated in each individual's "profile file." Users seem to migrate fairly rapidly to "expert" recognition modes, where a minimum number of characters will elicit recognition of command words. The fully spelled-out command words are presented in the Command Feedback Window as soon as they are recognized. The Backspace Key will cause backup, one command word at a time.

5c

Of the system requirements behind our choice of this noun-verb command form, two are particularly relevant here: (1) The "vocabulary" of the functions of the tools, and of the entities they operate upon, must be as extensible as is a natural language; (2) Textual lists of commands must conveniently lend themselves to writing, documenting, and executing as "macro" commands.

5d

Screen selection is done with a mouse. If the command's noun is a single, defined text or structure entity, e.g., a "word", then there is only one selection needed (e.g., to pick any character in the designated word).

5e

Besides using a standard keyboard for character entry, an AUGMENT user may optionally use a five-key, one-hand, chord keyset. Remarkably little practice is required in order to enter alphabetic characters, one hand-stroke per character. With less than five hours practice, a person can begin profitably working in a two-handed, concurrent mode -- operating the mouse with one hand and simultaneously entering command characters and short literal strings with the other hand.

5f

Here is an example of a low-level action which reveals some basic characteristics of high-performance execution. It is a very simple situation, but representative of what is met over and over and over again in doing hard knowledge work. The worker is composing or modifying something in one area of the screen, when his eye catches a one-character typo in another area. For a skilled AUGMENT worker, the typo could be corrected in less time than it would take someone to point it out to him -- with three quick strokes of the keyset hand during a casual flick of the mouse hand, and an absolute minimum of visual and mental attention taken from the other ongoing task.

5g

Fast, flexible, graceful, low effort -- these are important to all high-frequency, low-level, knowledge-work actions. This same kind of speed and flexibility are achieved by skilled AUGMENT workers in executing all of the other functional features described below. Description of mouse and keyset, and their concurrent employment, may be found in <Ref-7>.

5h

## ADDRESSING THE WORKING MATERIALS

6

There is a consistent set of addressing features that a worker may use in any command to designate a particular structural node or some element of text or graphics attached to that node. It adds appreciably to the power and flexibility of the system commands to have a rich, universally applicable vocabulary for directly addressing particular entities within the working files. Below are some examples.

6a

### EXPLICIT STATEMENT ADDRESSES

6b

There are four "handles" by which a given statement may be directly addressed:

6b1

**Structural Statement Number.** This designates the current "structural location" of the statement. It is assigned by the system, depending upon where the worker installs or moves a statement within an existing structure, or how that structure might have been re-organized subsequently. It is usually expressed as an alternating sequence of number-letter fields -- e.g. "1", "1a", "1a1", "1a2", and "1b". At a worker's option, these same statement numbers could be shown as "1", "1.1", "1.1.1", "1.1.2", or "1.2", but this bulkier alternative is seldom chosen.

6b2

**Statement Identifier, or SID.** This is a unique integer, assigned in sequential order by the system as each statement is first inserted, and which stays with a statement no matter how much its content may be altered or where it may be moved in its file structure. To make it uniquely recognizable for what it is, a SID is always displayed, printed, or designated with a prefixed "0" -- e.g., "012", "0417", etc. SIDs are particularly useful for referencing passages in a document while it is evolving.

6b3

**A Worker-Assigned Statement Name (or label).** For any statement or part of the file structure, an author can designate as "name delimiters" a pair of characters that indicate to the system when the first word of a statement is to be treated as a name for that statement. For instance, if "(" and ")" are set by the author as name delimiters for a specified part of the file, any parenthesized first word in a statement would be recognized by the system as that statement's name.

6b4

(Note: It is optional whether to have any of the above three identifiers displayed or printed with the statements' text.)

6b5

**A Direct Screen Selection.** When a statement to be designated is displayed in a window, usually the best way to "address" it is to use the mouse to position the cursor anywhere on the statement and depress the mouse's "Select" key (indicated below by "<Select>"). This mode is generally used for text manipulation -- selecting characters, words, numbers, visibles, invisibles, etc. (any of the text entities which have been made system recognizable).

6b6

## MARKERS

6c

As one "holds a place" in a book by leaving a temporary place marker in it, an author can place "markers" at arbitrary locations within an AUGMENT file. When placing a marker, he attaches it to a specific character in the text and gives it a name or label. Marker names are local to each file. Simple commands provide for displaying where one's markers are located and what their names are, for deleting or moving a marker, or for installing a new one.

6c1

A marker name may be included in an address expression, to provide another way of designating an address. A marker name can designate not only a particular statement, but a specific character within that statement. For example, "Copy Word #x (to follow word) <Select>" would designate that a word located somewhere in the file and marked with an "x" is to be copied to follow the cursor-selected word. There are many unique ways in which markers may be employed by an author who has integrated their artful use into her working methodology.

6c2

As a comparative example of some of the foregoing addressing forms, consider a statement whose SID is "069", whose statement number is "3b5", that has

statement-name delimiters designated for it as "NULL" and ":"; that starts with the text "Capacity: For every ...", and that has a marker named "x" positioned on one of its characters. A command to move this statement could optionally be expressed as:

6c3

"Move Statement <Select> ...",

6c3a

"Move Statement 3b5 ...",

6c3b

"Move Statement 069 ...",

6c3c

"Move Statement Capacity ...", or

6c3d

"Move Statement #x ...".

6c3e

## RELATIVE-ADDRESS EXTENSIONS

6d

A sequence of characters may be appended to the address of a given statement to specify an address of a position "relative" to that statement. A major class of these designations deals with relative structural location, such as: Up a level, Down a level, Successor at same level, Predecessor at same level, Head at this level, Tail at this level, and End statement at last and lowest position in this branch. A period (".") in the address string indicates that relative addressing is beginning, and each of these relative-location designators is indicated with a directly mnemonic, one-letter designation.

6d1

For example, "Move Statement 0609 (to follow statement) 4b.dt" would move Statement 0609 to follow the tail statement of the substructure one level down from Statement 4b -- or, to conceptualize the associated address-location pathway, "go to 4b, then Down a level and to the Tail".

6d2

## EMBEDDED CITATION LINKS

6e

A special use of address expressions is within an explicit text entity that we call a "Citation Link" (or "Link" for short). Links are used as textual citations to some specific file item within the workshop domain. A link is delimited by parentheses or angle brackets and contains a valid address string whose path leads to the cited file entity. For example, "(0306)" or "(4b.dt)" are valid links. Also, the reference items at the end of this paper are statements named "Ref-1", "Ref-2", etc., and as such can be cited with links "<Ref-1>", "<Ref-2>", etc. An AUGMENT reader may travel via such a link directly to the referenced bibliographic citation.

6e1

A special feature in AUGMENT's link provisions is the use of "indirect link referencing". In path-following terms, including ".l" in an address string stipulates, "scan forward from this point to the next link, and follow that link to

its target." For example, to follow the path prescribed by link "(4b.l)", one would "go to 4b, then find the first link in that statement and follow the path that it specifies." This latter path in turn could prescribe use of another link, etc. There is no intrinsic limit to the number of these indirect links that may be employed in a given path -- only a natural caution against such a path looping back upon itself.

6e2

As an example, note that "<Ref-1>" is a link to the statement named "Ref-1", a bibliographic citation at the end of this paper. In that citation, there is a link to the original source document of the referenced publication, permanently stored in the AUGMENT Journal as Item 71279 (the Journal is described below). The point to be made here is that with the link "<Ref-1.l>", I can reference the original source document -- and a Jump Link command would "take me there."

6e3

## TEXT AND CONTENT ADDRESSING

6f

Other addressing options include scanning for a content match, and/or stepping backward and forward a given number of characters or words (or other text entities). For instance, the foregoing link could have involved a bit more smarts in designating which link to follow: e.g., the path for '(4b "\*D".l)' would be "to 4b, scan for first occurrence of "\*D", then follow the next link found in that statement."

6f1

## OTHER-FILE ADDRESSING

6g

By preceding an in-file address string with a file address, and separating the two strings with a comma, one obtains a composite address designating a given entity within a given file. Extending this principle lets one prefix the file name with a directory name in which the file is to be found; and further, one can prefix this with a host-computer name.

6g1

For example, '(Office-5, Program-Documentation, Sequence-Doc, Specifications "Journal")' specifies the path: to the Office-5 host computer, to its Program-Documentation file directory, to its Sequence-Doc file, to its statement named "Specifications", and then scan to the location of the text "Journal".

6g2

If a person were working on the Office-5 host, he would only have to specify '(Program-Documentation, Sequence-Doc, Specifications "Journal")'. If he were already working within a file with its "link default" set to the Program-Documentation directory, he would only have to specify '(Sequence-Doc, Specifications "Journal")'. And if he were already working within the Sequence-Doc file, he would only have to specify '(Specifications "Journal")'. And if he were planning to reference items relative to the Statement named "Specifications" very often, he could affix a marker (e.g., named "s") to its front and would then only have to specify '('#s "Journal")'.

6g3

Or, suppose he were working in another file in a different directory on Office-5 and wanted to reference items relative to that same "far off" statement with special ease: in some temporary place in that file he could install a statement named "Ref" (for example) containing the textual link, "(Program-Documentation, Sequence-Doc, Specifications)". He could then cite the above reference with the link, '(Ref.1 "Journal")'. This path description is: go to the statement in this file named "Ref", take the first link that you find there (traveling across intervening directories and files and statements), and beginning in the statement on the other end of that link, scan forward to the string "Journal".

6g4

This is only a cursory treatment, but should illustrate well enough what is meant by "a rich and flexible addressing vocabulary." As with other high-performance features in AUGMENT, a beginner is not forced to become involved in the larger vocabulary in order to do useful work (with productivity on at least a par with some other, restricted-vocabulary system). But an AUGMENT worker interested in higher performance can steadily pick up more of the optional vocabulary and skills in a smooth, upward-compatible progression.

6h

## CONTROLLING THE VIEWS

7

A user of a book, or of most on-line text systems, is constrained to viewing the text as though he had a window through which he sees a fixed, formatted document. But as described below, our worker can view a section of text in many ways, depending upon his need of the moment.

7a

## MULTIPLE WINDOWS

7b

For whatever total screen area is available to the worker, his general performance will be improved significantly if he can flexibly allocate that area into arbitrary-sized windows whose contents can be independently controlled. AUGMENT has long provided this basic capability, along with the provision that material from any accessible file may be shown in any window, and also that screen-select copying or moving can be done across the different windows.

7b1

(Note: Cross-file editing can be done at any time, between any two legally accessible files. If one or the other file's material or destination is not being displayed in any of the windows, one may always opt to employ a textual address expression instead of a <Select> within any editing command.)

7b2

User-adjustable parameters are used to control the view presented on the display. Adjusting one's view parameters is a constantly used AUGMENT feature that has solidly proved its value. To facilitate their quick and flexible

use, the view-specification actions evolved into cryptic, single-character codes, called "viewspecs." The syntax of all Jump commands (used for traveling) includes the option of designating new viewspecs, and a special combination of mouse buttons enables quick, concurrent, keyset action to change the viewspecs for a given window. Here are a few of the frequently used view controls:

7b3

## WINDOW VIEWS

7c

**Structure Cutoff.** Show only the statements that lie "below" this statement in the structure (i.e., this "branch"); or show only those following statements that are at this level or deeper; or show all of the following statements that will fit in this window.

7c1

**Level Clipping.** For the designated structure cutoff, show only the statements down to a specified level. Lower-level statements are "clipped" from the view; the worker can thus view just a selected number of the upper levels of his document/file.

7c2

**Statement Truncation.** For those statements brought into view (as selected by other view specifications), show only their first n lines. Truncation to one line is often used, along with level clipping, in order to get an effective overview.

7c3

**Inter-Statement Separation.** For viewing ease -- blank lines can be optionally installed between statements.

7c4

(Note: The foregoing view controls are extremely helpful when studying and modifying a document's structural organization.)

7c5

**Statement Numbers and Names.** Optionally, for a given window, show the Statement Number (or the SID) of each statement -- with an option for showing them at either the right or at the left margin. Independently, the showing of statement names may be turned on or off.

7c6

**Frozen Statements.** A worker may select a number of statements, in random order, and designate them as "frozen." One of the view-specification options is to have the frozen statements appear at the top of the frame, with the rest of that window left for normal viewing and editing. The frozen statements may be edited, or even cross-edited between any other displayed (or addressable) statements.

7c7

**User-Specified Content Filters.** A simple content-analysis language may be used in a "Set Content Pattern" command, which compiles a little content-checking program. One of the view-specification options will cause the system to display only those statements which satisfy both the structure and level conditions imposed by other viewspecs, and which also pass the content-analysis test applied by this program. Where desired, very sophisticated

content-analysis programs may be written, using a full-blown programming language, and placed on call for any user.

7c8

**USER-SPECIFIED SEQUENCE GENERATORS**

7d

In the foregoing, a "view" is created by beginning at a designated location in a document (file) and selecting certain of the the "following" statements for display, according to the viewing parameters -- possibly suppressing statements that don't pass the test of a content-analysis program. This is essentially a "parameterized sequence generator," and provides very useful options for selectively viewing statements within a document; however, it works only by selectively discarding statements from a sequence provided in standard order.

7d1

Application programmers can provide alternate sequence-generator programs, which any user can invoke in a straightforward manner. In such a case, the apparent structure being presented to the user could be generated from a sequence of candidate statements according to any rules one may invent -- and the actual views could be further controlled by the above-described viewspecs for level clipping, truncation, content filtering, etc.

7d2

Perhaps the most commonly used, special sequence generator is one that provides an "Include" feature, where specially tagged links embedded in the text will cause their cited passages to be "included" in place of the Include-Link statements, as though they were part of this file. This provision enables arbitrary assemblage of text and formatting directives, from a wide collection of files, to represent a virtual, one-document, super file. For instance, the whole assemblage could be passed to the formatter, by means of a single user action, to generate a composite, photo-typeset document.

7d3

**TRAVELING THROUGH THE WORKING FILES**

8

An important provision in AUGMENT enables an author to freely "travel around" in his on-line file space to reach a particular "view point" of his choice -- i.e., the position within a file from which the system develops the desired form of "view" according to the currently invoked view specifications.

8a

Traveling from one view point to another is accomplished by Jump commands, of which the simplest perhaps is a direct Jump to a statement designated by a screen selection. Then, for a worker grown used to employing address strings, a next form would be a Jump on an embedded link, or to a statement designated by a typed-in address string -- using any combination of the addressing elements and viewspecs described above. For example, the link "<4b:mI>" points to the Statement 4b, while invoking viewspecs "m" and "I" which cause the statements' SIDs to be displayed. The link "<Ref-1.l:i;LL>" points to the document referenced by the link in the statement named "Ref-1",

invoking viewspec "i" for user content filtering, and sets the filter to "LL" to show only those statements beginning with a lower-case letter. The applications are effectively endless.

8b

## MODIFYING THE DOCUMENT STRUCTURES

9

Given the array of capabilities described above, it is very simple also to provide for very flexible manipulation of the file structure. For operating on a small, basic set of structure-entity nouns, essentially the same basic verbs may be used as for text manipulation -- i.e. Insert, Delete, Move, Copy, Replace, and Transpose are quite sufficient for most cases. For instance, "Move Branch 2b (to follow) 3c" immediately moves Statement 2b and all of its substatements to follow Statement 3c -- and their statement numbers are automatically changed from 2b, 2b1, etc., to 3d, 3d1, etc.

9a

A few extra verbs are useful for structure manipulation. For instance, a "Break" command will break a given statement off at a designated point in its text string, and establish the rest of the text as a new, separate statement. And an "Append" command does the reverse -- i.e., it appends the text of one or more existing statements to the end of a designated statement.

9b

A major source of structure-modification capability derives from the associated "studying" capabilities. For example, if an author can view a file (document) with specifications that show him only one line each of just those statements in the top two levels, he gets an overview of the high-level organization that helps immensely to study his current structure or outline.

9c

Concurrent use of mouse and keyset also provide considerable gains in speed and flexibility for studying and modifying document structure. For example, if when studying the overview described in the previous paragraph, the author perceives that Statement 2b really belongs in Section 3, following Statement 3c, he can execute the necessary move command in a very quick, deft manner:

9d

Keyset hand strikes "m" and "b" (for Move Branch), while the mouse hand is positioning the cursor anywhere in the text line of Statement 2b. [Two chord strokes.]

9d1

The mouse hand depresses the <Select> button on the mouse while the cursor is on Statement 2b, then moves to Statement 3c and depresses it again, and then depresses it again to say, "OK, do it." [Three button pushes, synchronized with the mouse movement as it made two selections on easy, window-wide, whole-line targets.]

9d2

(Note: I just had myself timed for this above operation -- an unhurried 2.5 seconds.)

9e

In our view, interactive computer support offers an author a priceless opportunity to get away from the geometric bondage inflicted by pages, margins, and lines -- things which have very little if any bearing upon the content and organization of one's text. In terms of value to the authoring process, we differ sharply from those who advocate a "What you see is what you get" working mode during the development of a document's content and organization. For this kind of work, experienced users of the foregoing kind of flexible facility for addressing, viewing, and manipulating structured documents, would consider a "What you see ..." mode as a relative handicap.

9f

## SUPPORTING MULTI-PARTY COLLABORATION

10

The support that advanced technology can provide for close collaboration among knowledge workers is a very important and much under-rated possibility. For multiple-author activities, collaborative support is an important aspect of system capability. Some years ago, we introduced the following provisions into AUGMENT. (A more complete, overview treatment of these is given in <Ref-8>.)

10a

**Electronic Mail.** Its primary attributes of speed, automatic distribution, and computer-to-computer directness are well recognized -- and are generally accepted now as important to the effectiveness of knowledge workers. AUGMENT Mail has features that are beyond what most electronic mail systems offer, and which provide unique benefit to the authorship process.

10b

AUGMENT's mail system allows one to "send" complete, structured documents as well as small messages. In an authorship environment, an important role for "electronic mail" is for the control and distribution of documents -- where small, throw-away messages are considered to be but a special class of document. An author should be able to bundle up any combination of text and graphics, in the forms that he has been using for studying and manipulating them -- and send the bundle to other workers. In AUGMENT, such a bundle is just like any other file structure, and can be studied and manipulated, incorporated into other files (documents), saved or deleted.

10b1

**Recorded Mail -- AUGMENT'S Journal System.** When mailing a document, an AUGMENT worker may optionally specify that it be installed as a "recorded" item. In this case, before distributing the item, the system will make a permanent record of it, as a file in a specified Journal collection. And, just as though it had been published, this recorded Journal item cannot later be changed. The system assigns a straightforward accession identifier (a simple number), and any authorized worker is henceforth guaranteed access to that Journal item by specifying the name of the Journal-collection and the Journal-item number -- e.g., as specified in the link "<OAD,2237,>".

10c

A given journal may be set up to serve multiple hosts and is much like a special library. It has its collection of documents, and AUGMENT provides associated support processes for entry, cataloging, retrieval, and access.

10c1

Together with the linking capability described above, a Journal system provides an extremely effective form of "recorded dialog." Cross-reference links between a succession of Journal items produces an inter-linked network of collaborative contributions -- plans, outlines, document drafts, schedules, short comments, detailed critiques, reference material, etc. The on-line worker can follow these links very easily and, using multiple windows and flexible viewing options, can make very effective use of such records.

10c2

For instance, consider a detailed commentary directed toward a "preliminary design" document recorded in a given Journal collection. The author writing the commentary could view the design document in one window and his developing commentary document in another. He can easily establish links in his commentary to cite any passage in the design document -- e.g., a statement, a term in the statement, or a diagram. Then this author would submit his commentary into the Journal, perhaps specifying a list of colleagues for "distribution." Each listed user would automatically receive a mail item announcing this new Journal entry, giving subject, author, date, etc., and the all-important link to the new Journal file containing the commentary. Any such recipient can subsequently study both the commentary and its cited planning document in a similar, multi-window, link-assisted manner.

10c3

Furthermore, this second reader could develop and submit his own recorded commentary, which because of the citation power of AUGMENT links could be as short and to the point as: "Frankly, John, I think your comment in (DDD,xxx,aa) is a mistake! Didn't you notice the earlier assumption in (DDD,xxx,bb)? Maybe you should go back to Tom's earlier requirements document -- especially at (EEE,yy,cc)." (Here, "DDD" and "EEE" represent Journal names, "xxx", "yyy", and "zzz" represent Journal item numbers, and "aa", "bb", and "cc" represent addresses pointing to specific passages in those Journal files.)

10c4

In official parlance, "retrieval" is the finding out about the existence of a relevant piece of information, whereas "access" is the subsequent process of gaining possession of the information. For users of AUGMENT's Journal system, retrieval is immensely facilitated by the widespread use of citation links. When one can follow them as easily as can a practiced AUGMENT worker, these links provide extremely effective retrieval support. We have supplemented this with some simple, automatically generated catalog files, which made a rather nice balance. Access is provided by direct Jump on a reference link if the file is on line; if it isn't, AUGMENT asks the worker if she wants it retrieved, and a simple affirmative response automatically launches a request for the system operator to retrieve the file from its archive tape, after which the worker is notified of its availability via electronic mail.

10c5

A private document can be submitted into a Journal. In this case, only those workers listed at Journal-entry time can get access to the central copy. Such a private item would not be listed or indexed in the "public" catalogs.

10c6

We have used the Journal system very heavily since 1970 to support AUGMENT's development activity; many customers have employed it heavily since 1975. There are about 100,000 entries recorded in the original Journal now (I don't know about other, newer AUGMENT Journal collections). We found that as workers became at home in this environment, they were increasingly free about submitting their items to the "public." It became evident that the scientific tradition of active and open interchange has some solid relevance to the collaborative processes in our smaller, "colleague communities." Time and again a worker would come across others' dialog and be able to contribute some valuable information (sometimes a one-sentence comment with a critical citation link). Often the payoff went the other way: the new party found immediate value in an old piece of recorded dialog.

10c7

**Shared-Screen Teleconferencing.** Consider a case where two people sit down to work together at a terminal, where they can both see the screen(s), and where either one can take over the controls. This is being done countless times every day throughout the country, in different combinations of expert-expert, expert-novice, novice-coach, etc. When talking together on their telephones, two or more distantly separated AUGMENT users can collaborate in a manner very similar to this.

10d

Suppose that two workers, Smith and Jones, want to set up and operate in a Shared-Screen Conferencing mode. Smith is in Princeton, working on host Office-4, and Jones is in San Francisco, working on host Office-12 -- and both of these host computers are connected to the same network. Assumedly they are in telephone contact when they decide to work in this shared-screen mode to collaborate on Smith's current job.

10d1

Jones will enter the command "Share (display with user) SMITH! On host OF12! Viewing (other display)!!"

10d2

Smith will enter the command "Share (display with user) JONES! On host OF4! Showing (this display)!!"

10d3

To give these commands, each person only entered the characters shown in upper case (entry case actually irrelevant), plus the digits, plus an "OK Key" action where each exclamation point is shown.

10d4

Whatever tool that Jones is currently using will continue responding to his controlling actions, as evidenced by various feedback and portrayal actions in the windows on his screen. Smith's screen image will clear, and be replaced with a replica of Jones' screen image -- multiple windows and all. For the duration of the shared-screen session, Smith's screen image will continue to replicate what is shown on Jones' screen.

10d5

There are provisions for passing control back and forth between workers. For instance, Jones can pass control to Smith so that Smith can show him some material or method of work. There are also provisions for the subsequent entry and departure of other conference participants.

10d6

## EMBEDDING THE GRAPHIC ILLUSTRATIONS

11

For complete support of document development, it is important to provide integrated means for developing, viewing, and manipulating graphical portrayals. These portrayals should be part of the working files from the very start, to be studied, passed about in mail, shared in Conferencing mode, edited, captioned, labelled, and moved about within the document structure.

Furthermore, active, relevant citation links pointing to these graphical constructs would be installed in and followed from textual passages throughout the associated set of documents (including Mail and Journal documents).

11a

AUGMENT's architecture and file structure were designed for this end, and a good bit of the associated implementation is in place.

11b

A graphical data structure can be attached to any given file node, and there are basic capabilities for composing, studying, and modifying graphical diagrams. When formatting for a suitably equipped photo-typesetting device, there are formatting directives to designate the position and scale for placing these diagrams on a page. An AUGMENT file with integrated text and graphics can thus be mapped automatically onto a high-quality document whose pages contain both text and line drawings.

11c

Our goal here was for what we call an "illustrative graphics" capability -- basic to which is a command that, when directed toward any conventional "plotter" file, will translate it into a diagram attached to a designated node. In this way we can make use of graphic constructs developed within almost any applications system, most of which have provision for outputting "conventional" plotter files.

11d

The most important next step is to adapt a bit-mapped display as an AUGMENT workstation, so the integrated text and graphics can be viewed and manipulated on the same screen. Heretofore, to do graphic work, an author has had to attach a Tektronix 4014 storage-tube display to the special printer/graphic port of her AUGMENT workstation. This has made use of AUGMENT graphics slow and expensive enough to limit the number of user groups who have developed the integrated use of mixed text and graphics.

11e

## CONCLUSION

12

AUGMENT's unique provisions stemmed for the most part from the conceptual framework within which AUGMENT was developed. For instance, consider the pervasive and significant changes in the environment in which humans will be doing their knowledge work. Note that the habits, methods, conventions, intuitions, etc., that comprise the "ways" in which we think, work and collaborate, are for the most part products of many centuries of cultural evolution -- in a radically different environment. With a radically different environment, this constant process of cultural evolution can be expected to take some radical turns.

12a

The AUGMENT developmental framework assumed that many of these "ways" are candidates now for change in directions that heretofore would not have been beneficial. The AUGMENT system emerged as a first step in considering a few such changes, which perhaps can improve human capability for doing knowledge work because their new "ways" will enable us more effectively to harness the new tools toward more effective basic capability. (This is very different from trying to "automate" our old "ways" of doing things.)

12b

As an example, consider the "What You See Is What You Get" (WYSIWYG) syndrome. It is a highly touted feature for many vendors. It provides a definite advantage for the final process of converting a computer-held document to a nicely formatted hard copy. But what does it do for authorship? Well, in our framework, it has a negative impact. We were happy to abandon those constraints of lines and pages and other formatting geometry which did not contribute to matters of content and structure. We have chosen instead to provide the authorship process with structured files, flexible addressing, flexible window-size viewing, level and truncation viewspecs, etc. -- things that would be awkward or impossible to provide in a WYSIWYG environment. This provides the authorship phase with flexibility and power for studying and manipulating content and structure that we wouldn't consider trading off for WYSIWYG. Save it for the production phase.

12c

Here is another bit of culture that deserves re-examination. Consider the dictum, "Easy to learn, and natural to use." Or, "User friendly." The question is, for whom are you judging that things will be easy, or natural, or friendly? For designers of craft-work tool systems, very different perceptions of this issue are warranted between a system for the occasional, weekend do-it-yourself person and a system to be heavily used day after day by professionals. The AUGMENT User Interface System enables us easily to configure either kind of a tool collection.

12d

This paper describes part of what is provided to professional knowledge workers who do a significant amount of authorship work. We observe no more difficulty in their learning how to employ this relatively large collection of tools

than one would expect for professional woodworkers in their learning about the relatively large collection of chisels and other tools of their trade.

12e

It is a basic part of our framework that, to augment human knowledge workers, attention must be given not only to tools, but to methods and skills as well. Because of space limitations, the scope of this paper was restricted to a summary of those tool provisions within AUGMENT that especially facilitate the authorship process. A full description of "How to use AUGMENT to ..." would definitely need to include methods of work that effectively harness these tool provisions, and the special kinds of skills that yield unique payoff in executing these methods. This is true for every tool system, of course, but it seems especially true in this case because many AUGMENT provisions do not fit into the general cultural background of our authorship process.

12f

Perhaps the best way for very brief summarization of what AUGMENT's users feel about its unique features is simply to say that those who leave its working environment really miss them.

12g

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13

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